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NATIONAL DAM SAFETY PROGRAM. SHACKAMAXON DAM (NJ00369), RAHWAY --ETC(U)
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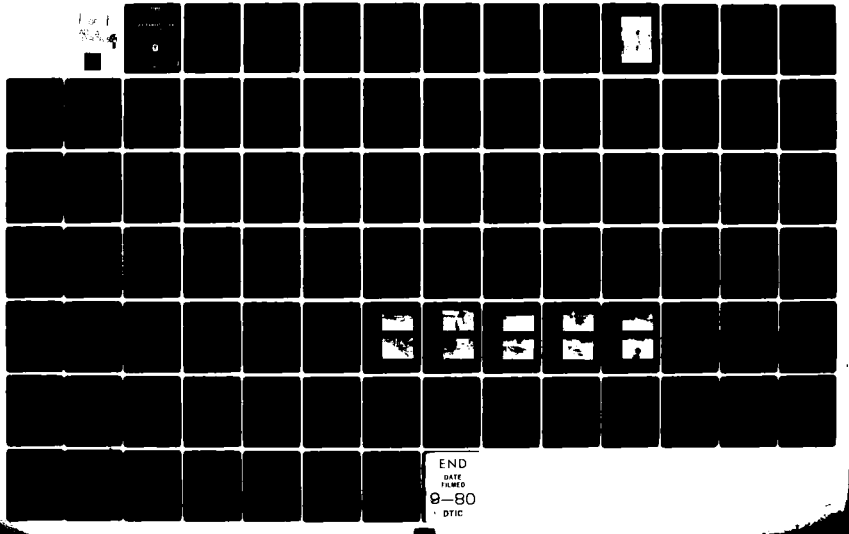

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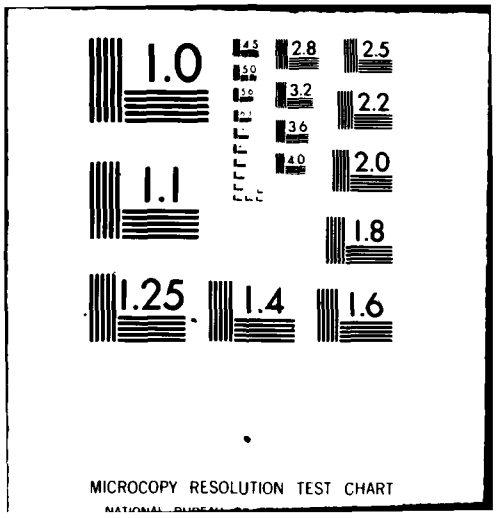
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LEVEL II

(1)

RAHWAY RIVER BASIN
LAMBERT'S RUN, UNION COUNTY
NEW JERSEY

SHACKAMAXON DAM
NJ 00369

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

(6) Shackamaxon Dam (NJ 00369) Rahway River Basin. Lambert's Run, Union County New Jersey. Phase 1 Inspection Report.

(9) Final rept.

(10) Richard J. McDermott

(15) DACW61-79-C-0011

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

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READ INSTRUCTIONS BEFORE COMPLETING FORM

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7. AUTHOR(s): RICHARD J. McDERMOTT	8. CONTRACT OR GRANT NUMBER(s): DACW61-79-C-0011
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Dams	National Dam Safety Program
Embankments	Shackamaxon Dam, New Jersey
Visual Inspection	Spillway
Structural Analysis	Seepage
	Erosion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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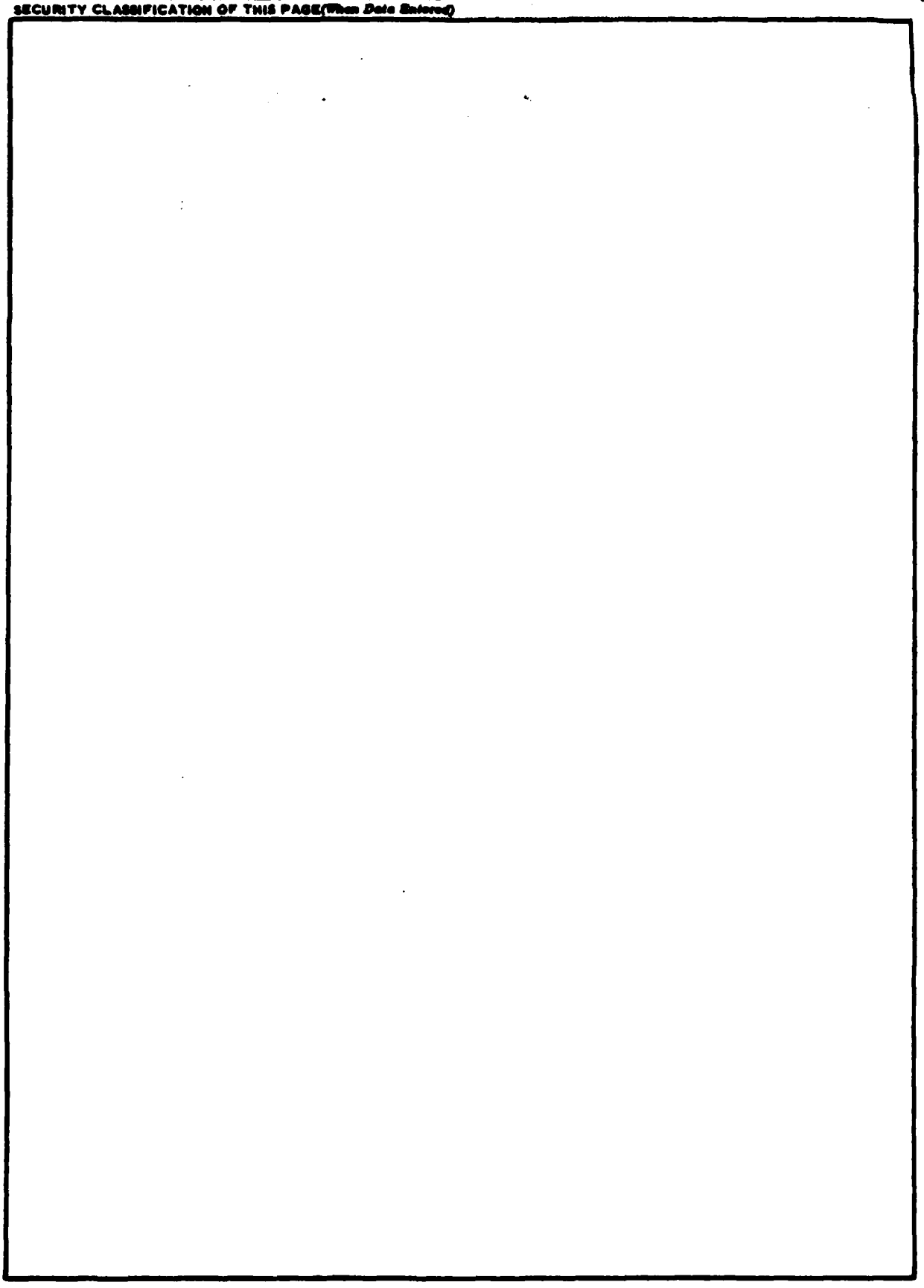

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

04 AUG 1980

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Shackamaxon Dam in Union County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Shackamaxon Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 42 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The owner should develop an emergency action plan and downstream warning system within six months from the date of approval of this report.

b. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

c. Within six months from the date of approval of this report, the owner should:

(1) Have the concrete rubble removed from the toe area and a determination made whether the observed seepage is the normal toe drain function.

(2) Drawdown the lake to thoroughly inspect the spillway and make any necessary repairs.

NAPEN-N
Honorable Brendan T. Byrne

(3) Line the outlet works discharge channel with erosion protection material such as riprap. Properly grade and protect the dam toe area and remove adverse vegetation from the embankment.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Rinaldo of the Twelfth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

SHACKAMAXON DAM (NJ00369)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 15 November 1979 by Storch Engineers under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Shackamaxon Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 42 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The owner should develop an emergency action plan and downstream warning system within six months from the date of approval of this report.

b. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

c. Within six months from the date of approval of this report, the owner should:

(1) Have the concrete rubble removed from the toe area and a determination made whether the observed seepage is the normal toe drain function.

(2) Drawdown the lake to thoroughly inspect the spillway and make any necessary repairs.

(3) Line the outlet works discharge channel with erosion protection material such as riprap. Properly grade and protect the dam toe area and remove adverse vegetation from the embankment.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

APPROVED: 

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 9 July 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Shackamaxon Dam, NJ00369
State Located:	New Jersey
County Located:	Union
Drainage Basin:	Rahway River
Stream:	Lambert's Run
Date of Inspection:	November 15, 1979

Assessment of General Condition of Dam

Based on visual inspection, past operational performance and Phase I engineering analysis, Shackamaxon Dam is assessed as being in fair overall condition.

Hydraulic and hydrologic analysis indicate that the spillway is inadequate. Discharge capacity of the spillway is not sufficient to pass the designated spillway design flood (SDF) without an overtopping of the Dam. (The SDF for Shackamaxon Dam is equal to one-half the probable maximum flood.) The spillway is capable of passing approximately 21 percent of the probable maximum flood or 42 percent of the SDF. Therefore, the owner should in the near future engage a professional engineer experienced in the design and construction of dams to perform more accurate hydraulic and hydrologic analysis. Based on the findings of the analysis, the need for and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future.

1) Adverse vegetation should be removed from the embankment.

2) Concrete rubble should be removed from the toe area and the area properly graded and protected with a suitable ground cover.

3) With the concrete rubble removed, the observed discharge at the dam toe should be investigated to determine whether it is due to normal toe drain function or to uncontrolled seepage. If due to uncontrolled seepage, appropriate remedial measures should be taken to control or eliminate the seepage.

4) The spillway should be thoroughly inspected with the lake drawn down and any necessary repairs to deteriorated portions should be made.

5) The outlet works discharge channel should be lined with riprap or otherwise properly protected against erosion.

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to insure the safety of the dam.

Richard J. McDermott, P.E.

John E. Gribbin, P.E.

OVERVIEW - SHACKAMAXON DAM

29 NOVEMBER 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that the unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

SHACKAMAXON DAM, I.D. NJ00369

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) in cooperation with the Philadelphia District of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the State of New Jersey. Storch Engineers has been retained by the NJDEP to inspect and report on a selected group of these dams. The NJDEP is under agreement with the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Shackamaxon Dam was made on November 15, 1979. The purpose of the inspection was to make a general assessment of the structural integrity and operational adequacy of the dam structure and its appurtenances.

1.2 Description of Project

a. Description of Dam and Appurtenances

Shackamaxon Dam is an earthfill dam with a concrete and grouted stone free overflow spillway. A timber and steel bridge spans the entire length of the spillway and is supported by concrete abutments which also serve as training walls.

The spillway which is oriented approximately north-south has a length of 40.5 feet. It is constructed with poured concrete and grouted cobbles on both the upstream and downstream sides. The downstream face is constructed to be flush with concrete piers remaining from the original spillway.

The elevation of the crest of dam varies from 89.7 to 92.6, National Geodetic Vertical Datum (N.G.V.D.). The highest point of the dam is the top of bridge and the lowest point is at the location of the outlet works at the south end of the dam. The overall length of the dam, including spillway is 275 feet. The entire length of the dam crest is paved with an asphalt road. The upstream face of the dam is grassed and graded with a slope of 5 horizontal to 1 vertical. The downstream face is grass covered and graded with a slope of 5 horizontal to 1 vertical north of the spillway and is lined with grouted stones at a slope of 7 horizontal to 10 vertical south of the spillway.

The outlet works consists of a gated 15-inch reinforced concrete pipe with a box culvert section at the outlet end.

The elevation of the spillway crest is 84.5 (N.G.V.D.) and the downstream channel bed elevation is 68.6. The spillway discharges directly into a natural channel.

b. Location

Shackamaxon Dam is located in the Township of Scotch Plains, Union County, New Jersey. Constructed across Lambert's Run, a Tributary to Robinson's Branch, Rahway River, the dam impounds a pond used for the irrigation of Shackamaxon golf course. Principal access to the dam is by private paved road inside the golf course.

c. Size and Hazard Classification

Size and Hazard Classification criteria presented in "Recommended Guidelines for Safety Inspection of Dams," published by the U.S. Army Corps of Engineers are as follows:

SIZE CLASSIFICATION

	Impoundment	
	Storage (Ac-ft)	Height (Ft.)
Small	<1000 and ≥ 50	<40 and ≥ 25
Intermediate	≥ 1000 and $<50,000$	≥ 40 and < 100
Large	$\geq 50,000$	≥ 100

HAZARD POTENTIAL CLASSIFICATION

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (no permanent structures for human habitation	Minimal (Undeveloped to to occasional structures or agriculture)
Significant	Few (No urban developments and no more than a small number of inhabitable structures	Appreciable (Notable agriculture, industry or structures)
High	More than a small number	Excessive (Extensive community, industry or agriculture)

The following data relating to size and downstream hazard for Shackamaxon Dam have been obtained for this Phase I assessment:

Storage: 123 acre-feet

Height: 21.2 feet

Potential Loss of Life:

One dwelling located 600 feet from dam is about 6 feet above stream bed. A road bridge is located 1100 feet from dam. Residential area located beyond road bridge within downstream flood plain. Failure of dam could cause loss of more than a few lives.

Potential Economic Loss:

Dam is located within a residential area of Scotch Plains. Houses and roads are located within 1000 feet of dam.

Therefore, Shackamaxon Dam is classified as "Small" size and "High" hazard potential.

d. Ownership

Shackamaxon Dam is owned and maintained by Shackamaxon Golf and Country Club, Inc., Post Office Box 656, Westfield, N.J. 07091.

e. Purpose of Dam

The purpose of the dam is the impoundment of a lake used for irrigation of the golf course.

f. Design and Construction History

Shackamaxon Dam reportedly was constructed in or about 1900. Information relating to the original design and construction is not available. Following complaints about its poor condition the dam embankment and spillway were repaired in 1974.

g. Normal Operational Procedures

The dam and appurtenances are maintained by the maintenance crew of Shackamaxon Golf and Country Club. There is no fixed schedule of maintenance; repairs are made as the need arises. The lake reportedly has been lowered only for repairs and when directed by NJDEP.

1.3 Pertinent Data

a. Drainage Area	2.5 Square miles
b. Discharge at Damsite	
Maximum known flood at damsite	1200 c.f.s., May 1968
Outlet works at normal pool elevation	21 c.f.s.
Spillway capacity at top of dam (Elev. 89.7)	1290 c.f.s.
c. Elevations (N.G.V.D.)	
Top of dam	Varies 89.7 to 92.6
Maximum pool-design surcharge	91.4
Normal pool	84.5

Spillway crest	84.5
Stream bed at centerline of dam	68.5
Maximum tailwater	72.0 (Estimated)

d. Reservoir

Length of maximum pool	2100 feet
Length of normal pool	1400 feet

e. Storage (Acre-feet)

Spillway crest	53 Acre-feet
Design surcharge	156 Acre-feet
Top of dam (Elev. 89.7)	123 Acre-feet

f. Reservoir Surface (Acres)

Spillway crest	11.0 Acres
Top of dam (Elev. 89.7)	16.2 Acres
Maximum pool-design surcharge	17.5 Acres

g. Dam

Type	Earthfill
Length	275 feet
Hydraulic Height	21.2 feet
Structural Height	24.1 feet
Side slopes - Upstream	5 horiz. to 1 vert.
Downstream	Varies 5 horiz. to 1 vert. to 7 horiz. to 10 vert.
Zoning	Impervious blanket on upstream side (added in 1974)
Impervious core	Unknown
Cutoff	Unknown
Grout curtain	Unknown

h. Diversion and Regulating Tunnel N.A.

i. Spillway

Type	Uncontrolled masonry weir
Length of weir	40.5 feet
Crest elevation	84.5
Gates	N.A.
Upstream channel	N.A.
Downstream channel	Natural stream

j. Regulating Outlets

15" RCP regulated by lift gate at upstream end.

SECTION 2: ENGINEERING DATA

2.1 Design

No plans or calculations pertaining to the original construction of the dam could be obtained. However, engineering data relating to the reconstruction design in 1972 is available. Construction drawings titled "Plan and Sections of Shackamaxon Dam" (5 sheets) by Luster and Luster, Inc., Civil Engineers and Land Surveyors, 193 South Avenue, Fanwood, N.J. include the following:

1) Plan and Section of "Shackamaxon Dam"
2) Profile and Section of "Shackamaxon Dam"
3) Details of "Shackamaxon Dam"
4) Details of "Shackamaxon Dam"
5) Cross Sections of "Shackamaxon Dam"

Construction specifications for the repair work are also available in the NJDEP file.

In addition, a design report prepared by Terratech Engineers, Inc. in October 1970 is available. The report, titled "Report to the Board of Trustees, Shackamaxon Country Club, Hydraulic and Structural Analysis, Shackamaxon Country Club Lake and Dam," contains the following:

1) Hydraulic/hydrologic analysis based on a 15-year frequency storm used to establish a new dam crest elevation and thus increase the capacity of the spillway to prevent overtopping of the dam.

2) Soils and geological report describing generalized dam site conditions based on available literature and subsurface investigations consisting of two borings and several probes.

3) Soils analysis of embankment based on borings and seepage investigation. According to the analysis, the embankment fill consists of a predominance of Clayey Silt intermixed with Sands, Gravels, Cobbles and Boulders and is founded on sandstone and shale bedrock.

According to the analysis, cavities have been created in the earthfill section of the dam and possibly in the spillway section as well. The erosion was caused by the flow of water into, through and out of the earthfill structure.

A stability analysis indicated that the dam was stable against a translational type failure and that with the successful sealing of the embankment against seepage it would be stable against rotational failure.

The Terratech report made the following recommendations for remedial measures:

1) Construct a barrier by sealing an observed major crack in the then existing upstream rubble wall using a gunite coating with the aid of expanded metal mesh fabric.

2) Attempt to fill the cavities and passages in the embankment using a low pressure inject grout similar to "Siroc 132".

3) Raise the dam profile to form a dam crest elevation of 190.0. This would involve the construction of new bridge abutments which would be carried to rock.

2.2 Construction

No data or reports pertaining to the original construction of the dam are available.

According to plans, specifications and correspondence in the NJDEP file, the repair construction in 1974 involved the following:

1) Excavation of muck on the upstream side of the embankment and the placement of an impervious fill blanket.

2) Grouting of voids in the original embankment.

3) Installation of an 8-inch toe drain on the downstream side of the embankment on the right side of the spillway.

4) Construction of new concrete bridge abutments resting on original concrete piers founded on rock.

5) Construction of a steel and timber bridge.

6) Placing fill on the crest and upstream side of the embankment to raise the dam profile.

7) Paving a road on the crest and installing timber guide rails.

8) Extending the outlet pipe upstream to accommodate the new grading of the upstream face of the embankment.

Susbequent to construction, concrete measuring weirs were installed upstream and downstream from the dam.

Although crushed stone and riprap slope protection were specified on the plans, no riprap was observed at the time of inspection.

2.3 Operation

No records of operation and maintenance of the dam subsequent to construction are available. Reports of inspections made by the State of New Jersey in 1951 indicated that "A stream of water of at least 500 g.p.m. was coming around the toe of the right downstream wingwall." Remedial measures by filling the opening at the crest of dam was suggested. In 1968, it was reported by the Country Club staff that the right embankment of the dam was washed out and then reconstructed. It was also reported that the dam was overtopped by 2 feet in 1971. The State of New Jersey ordered the lake to be dewatered after the 1971 inspection until improvements could be made to insure the safety of the dam. Lake elevation records during 1972 and 1973 documenting the maintenance of a partially drawn down lake pending repairs is available in the NJDEP file.

2.4 Evaluation

a. Availability

Available engineering information is limited to that which is on file with NJDEP including correspondence, inspection reports, plans and specifications for the reconstruction in 1974. A hydraulic and structural design report for the reconstruction is also available in the file.

b. Adequacy

Available engineering information is of significant assistance to the performance of a Phase I evaluation. A list of absent information is included in paragraph 7.1.b.

c. Validity

Information that could be verified was found to be valid within a reasonable allowance for error.

A crucial aspect of the 1974 repair was the raising of the dam profile to prevent overtopping. However, the design storm used at that time is considerably less severe than the SDF used for the present analysis.

The structural analysis appears to be valid and the repairs adequate provided that further investigation confirms that the observed discharge at the toe is due to flow in the toe drain and that the quantity of flow is within acceptable limits.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The inspection of Shackamaxon Dam took place on November 15, 1979 by members of the staff of Storch Engineers. A copy of the visual inspection check list is contained in Appendix 1. The following procedures were employed for the inspection:

1) The embankments of the dam, appurtenant structures and adjacent areas were examined.
2) Areas of suspected seepage were noted and located.
3) The embankment and appurtenant structures were measured and key elevations determined with the use of a surveyor's level.
4) The embankment, appurtenant structures and adjacent areas were photographed.
5) Depths of water were measured at various locations in the lake.

b. Spillway

The downstream side of the spillway appeared to be founded on red shale bedrock. The core of the spillway is reported to be earthfill, and the surface is grouted rubble walls for both the upstream and downstream side. The crest had a low section at the left end where most of the water was overflowing. The concrete surfaces appeared rough, irregular and of substandard quality workmanship. Deterioration was observed at the toe of the spillway where reinforcement was exposed.

The training walls, which also serve as bridge abutments appeared to be in good condition and of satisfactory workmanship. The bridge was in generally good condition.

c. Embankments

The upstream face of the embankment and downstream face of the south section of embankment were covered with a good stand of grass with some trees and brush noted. Trees and brush and rubble consisting of rocks and large pieces of concrete were noted at the toe of the south section of the embankment. Discharge of less than 1 gallon per minute was observed flowing at the toe from within the rubble. It could not be determined whether the discharge originated in the toe drain or was due to uncontrolled seepage.

No significant erosion or sloughing of the embankment was noted.

d. Outlet Works

The outlet conduit was entirely submerged or below grade and therefore not observed. The gate operating stem appeared to be in satisfactory condition, although it was not operated at the time of inspection. The sides of the outlet channel were significantly eroded with roots of small trees exposed.

e. Reservoir Area

Shackamaxon Lake is bordered by a golf course in all directions. A pump house for irrigation and two footbridges were observed within 300 feet upstream from the dam.

f. Downstream Channel

The spillway discharges directly into the downstream channel which consists of a stream flowing over exposed bedrock. Further downstream the channel is a natural stream with a high bank on the right and a more gradually sloping bank on the left. There is evidence on the right bank of erosion as high as four or five feet above the stream bed due to high water. A concrete notched weir is located 250 feet downstream where a small concrete and rock dam once stood. Two footbridges were observed at about 300 and 400 feet downstream. A dwelling, located 600 feet downstream from the dam, is about 6 feet above the stream bed.

A road bridge is located about 1100 feet downstream from the dam and a residential area of Scotch Plains lies beyond the bridge.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The level of water in Shackamaxon Lake is regulated naturally by discharge over the spillway of the dam. In addition, the water level drops in the summer when water is drawn for irrigation of the golf course. According to the NJDEP file, the most recent drawdown was ordered by the State of New Jersey in 1971.

4.2 Maintenance of the Dam

Reportedly, there is no program of regular maintenance of the dam and appurtenant structures. Maintenance is reported to be on an "as needed" basis and is performed by the Shackamaxon Country Club maintenance staff.

4.3 Maintenance of Operating Facilities

Maintenance of operating facilities is reported to be on an "as needed" basis.

4.4 Description of Warning System

According to the Shackamaxon Country Club maintenance staff no formal warning system is in use at the present time.

4.5 Evaluation of Operational Adequacy

Maintenance documentation is poor and the maintenance program for the dam appears to be insufficient in the following areas:

1) Trees and brush on embankment.
2) Possible seepage at the toe of embankment.
3) Deterioration of concrete at toe of spillway.
4) Concrete rubble accumulated at toe adjacent to right side of spillway.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The quantity of storm water runoff that the spillway should be able to pass without an overtopping of the dam is based on the size and hazard classification of the dam. This runoff, called the Spillway Design Flood (SDF), is described in terms of frequency or Probable Maximum Flood (PMF) depending on the extent of the dam's size and potential hazard. According to the "Recommended Guidelines for Safety Inspection of Dams," published by the U.S. Army Corps of Engineers, the SDF for Shackamaxon Dam falls in a range of 1/2 PMF to PMF. In this case the low end of the range, 1/2 PMF, is chosen because the factors used to select size and hazard classification are on the low side of their respective ranges.

The SDF hydrograph for Shackamaxon Dam was computed by use of the HEC-1-DB computer program using the SCS triangular hydrograph with the curvelinear transformation. Hydrologic computations and computer output are contained in Appendix 4. The calculated SDF peak inflow for Shackamaxon Dam is 3322 c.f.s.

Discharge capacity for the spillway was computed by considering free discharge over the masonry portion of the dam. Hydraulic computations are contained in Appendix 4.

The elevation of the crest of dam varies from 89.7 to 92.6. For purposes of overtopping analysis, the top of dam is assumed to be 89.7. The spillway capacity with water level at top of dam (elev. 89.7) was computed to be 1290 c.f.s.

A routing of the SDF through Shackamaxon Dam resulted in an overtopping of the dam by a depth of 1.7 feet. A breach analysis indicated that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream over that which would exist without failure. Accordingly, the subject spillway is assessed as being inadequate in accordance with criteria developed by the U.S. Army Corps of Engineers.

b. Experience Data

According to records in NJDEP files the dam has been overtopped in 1968 and 1971, prior to repairs in 1974 in which the dam profile was raised. The overtopping in 1971 was reportedly in excess of 2 feet over the dam crest.

c. Visual Observations

No evidence was found at the time of inspection that would indicate that the dam had been recently overtopped.

d. Overtopping Potential

As indicated in paragraph 5.1.a., a storm of magnitude equivalent to the SDF would cause overtopping of the dam by a height of 1.7 feet above the top of the dam. The spillway is capable of passing approximately 21% of the PMF or 42% of the SDF with lake level equal to the top of the dam (elev. 89.7).

e. Drawdown Data

Drawdown of the impoundment of Shackamaxon Dam is accomplished by opening the 15-inch gate at the south end of the dam. Total time for drawdown is estimated to be approximately 7 days. (See Appendix 4.)

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The embankment appeared, at the time of inspection, to be outwardly stable. However, the nature of discharge at the toe of dam should be investigated further to determine if it originates in the toe drain or is due to uncontrolled seepage.

b. Generalized Soils Description

The generalized soil description of the dam site consists of recent alluvium, composed of stratified materials deposited by streams, overlying glacial ground moraine deposited during the Wisconsin glaciation. The glacial moraine is composed of silts and silty sands and overlies shale and sandstone bedrock.

c. Design and Construction Data

Structural stability analysis performed in connection with the repair design in 1970 indicated that the dam is stable against a translational type failure and that with the successful sealing of the embankment against seepage it would be stable against rotational failure.

d. Operating Records

No operating records are available for the dam. Inspection reports made by the State of New Jersey in 1951 disclosed that the embankment had a serious leakage problem. Reportedly, the south embankment was washed out in 1968 and was

subsequently repaired. An inspection report made in 1971 suggested that repair was not acceptable due to extensive seepage and eroded embankment and the dam was repaired again in 1974. However, no inspection reports subsequent to the repairs in 1974 are available.

e. Post Construction Changes

According to records in NJDEP files, the south embankment of the dam was washed out in 1968 and rebuilt soon afterwards. In 1971, the dam was declared unsafe by State of New Jersey and an order to dewater the lake was issued. In 1972, alteration design was prepared by Luster and Luster Inc. of 193 South Avenue, Fanwood, N.J. The profile of the dam was raised to accommodate a 15-year flood level, and the embankment was repaired to control seepage.

f. Seismic Stability

Shackamaxon Dam is located in Seismic Zone 1 as defined in "Recommended Guidelines for Safety Inspection of Dams" which is a zone of very low seismic activity. Experience indicates that dams in Seismic Zone 1 will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. Shackamaxon Dam appeared to be stable under static loading conditions at the time of inspection.

SECTION 7: ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Safety

Based on hydraulic and hydrologic analyses outlined in Section 5 and Appendix 4, the spillway of Shackamaxon Dam is assessed as being inadequate.

The dam appeared at the time of inspection to be structurally outwardly stable.

b. Adequacy of Information

Information sources for this study include 1) field inspections, 2) USGS quadrangle, 3) aerial photography, 4) correspondence and inspection reports in NJDEP file, 6) consultation with representative of the Shackamaxon Country Club 7) design of reconstruction by Luster and Luster, 193 South Avenue, Fanwood, N.J. 1972.

The information outlined is sufficient to allow a Phase I assessment as outlined in "Recommended Guideline for Safety Inspection of Dams."

Some of the absent data are as follows:

1) Original design and construction plans of the dam.
2) Maintenance documentation.

c. Necessity for Additional Data/Evaluation

Additional data and evaluation is not considered necessary.

7.2 Recommendations

a. Remedial Measures

Based on hydraulic and hydrologic analyses outlined in paragraph 5.1.*a.*, the spillway is assessed as being inadequate. It is therefore recommended that a professional engineer experienced in the design and construction of dams be engaged in the near future to perform more accurate hydraulic and hydrologic analyses. Based on the findings of these analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan togeth r with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future.

1) Adverse vegetation should be removed from the embankment.

2) Concrete rubble should be removed from the toe area and the area properly graded and protected with a suitable ground cover.

3) With the concrete rubble removed, the observed discharge at the dam toe should be investigated to determine whether it is due to normal toe drain function or to uncontrolled seepage. If due to uncontrolled seepage, appropriate remedial measures should be taken to control or eliminate the seepage.

4) The spillway should be thoroughly inspected with the lake drawn down and any necessary repairs to deteriorated portions should be made.

5) The outlet works discharge channel should be lined with riprap or otherwise properly protected against erosion.

b. Maintenance

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to insure the safety of the dam.

PLATES

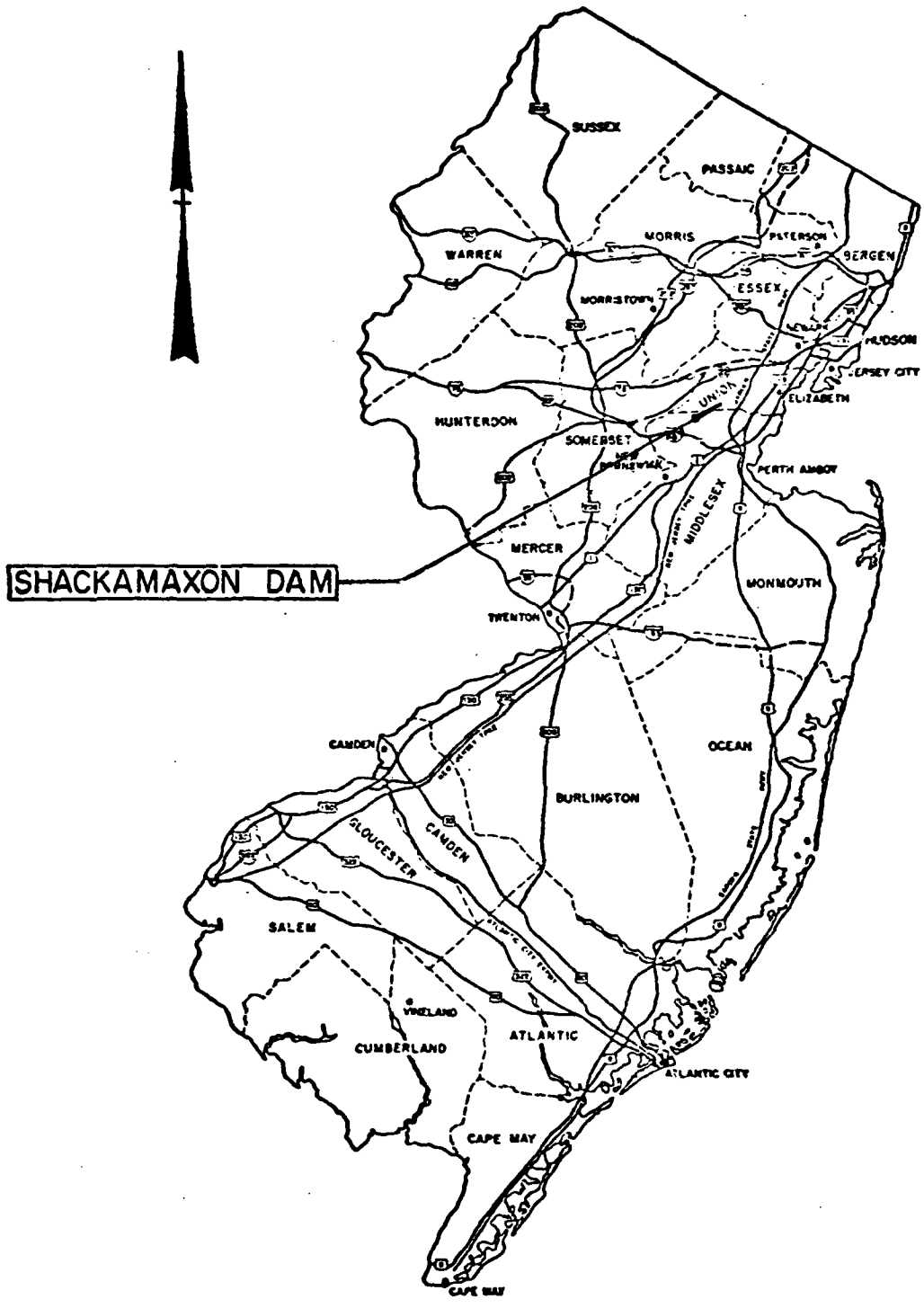


PLATE 1

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS KEY MAP SHACKAMAXON DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00369 — SCALE: NONE DATE: NOV., 1979

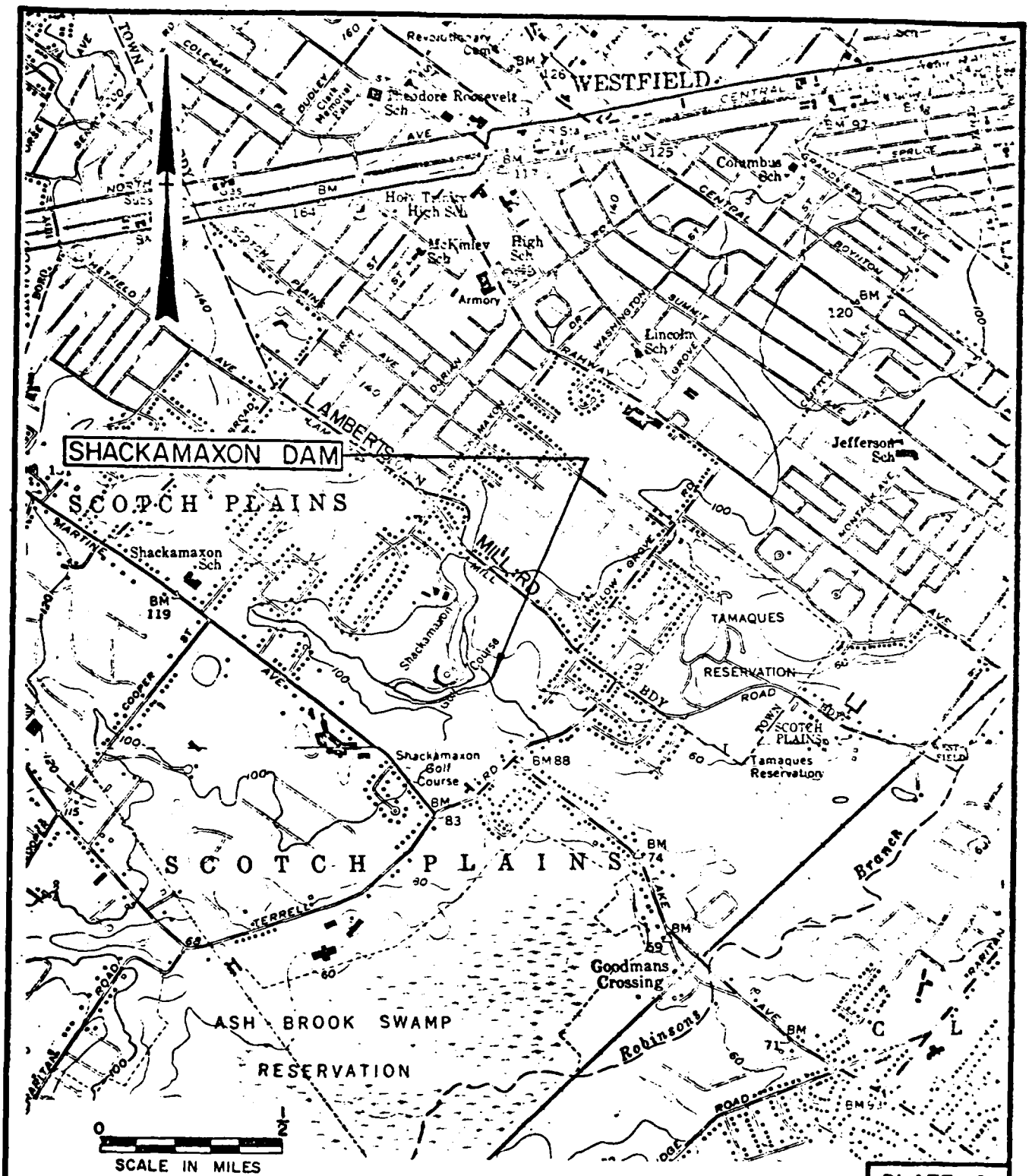


PLATE 2

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

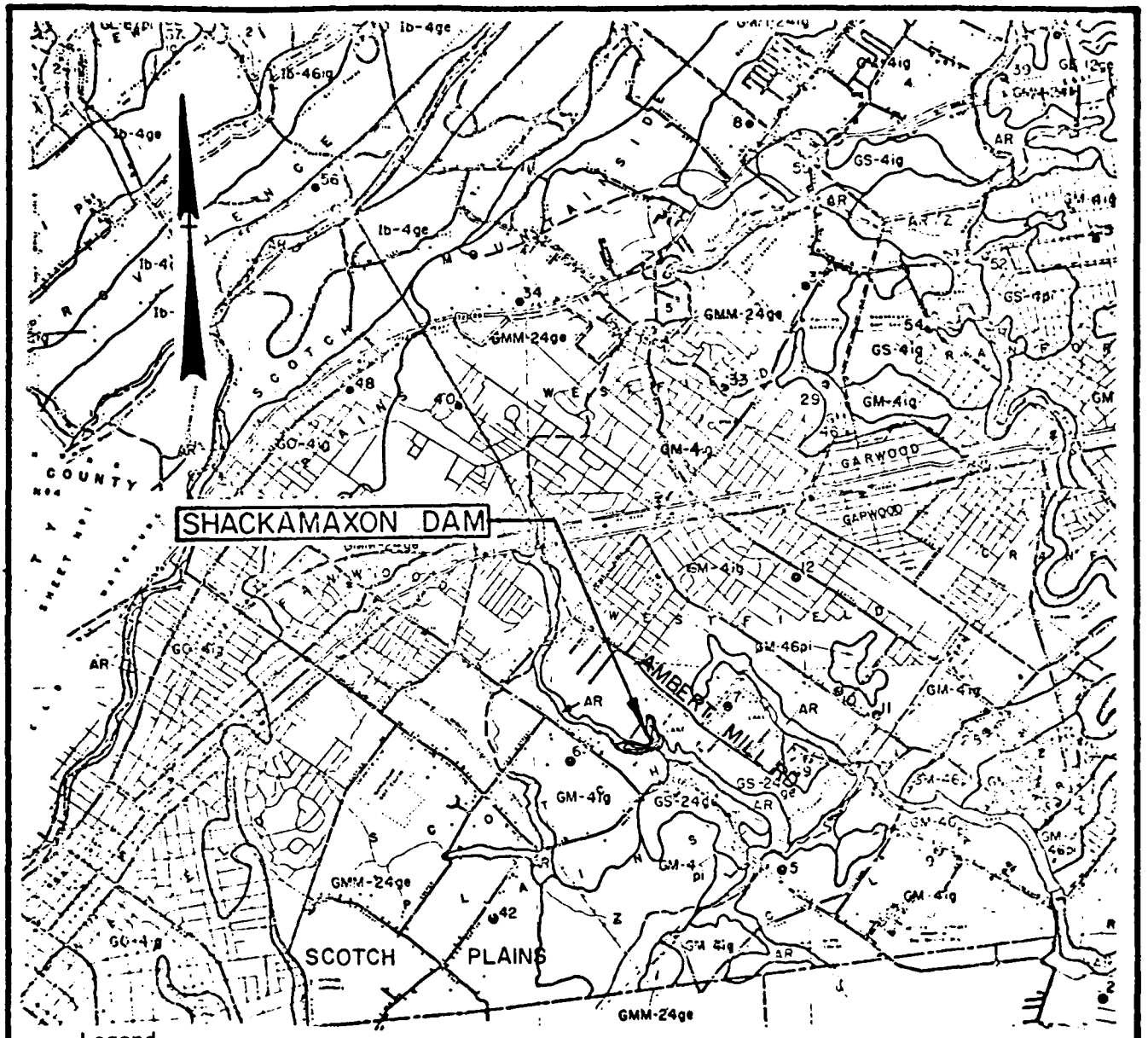
DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

VICINITY MAP

SHACKAMAXON DAM

I.D. N.J. 00369	SCALE: AS SHOWN
	DATE: NOV., 1979

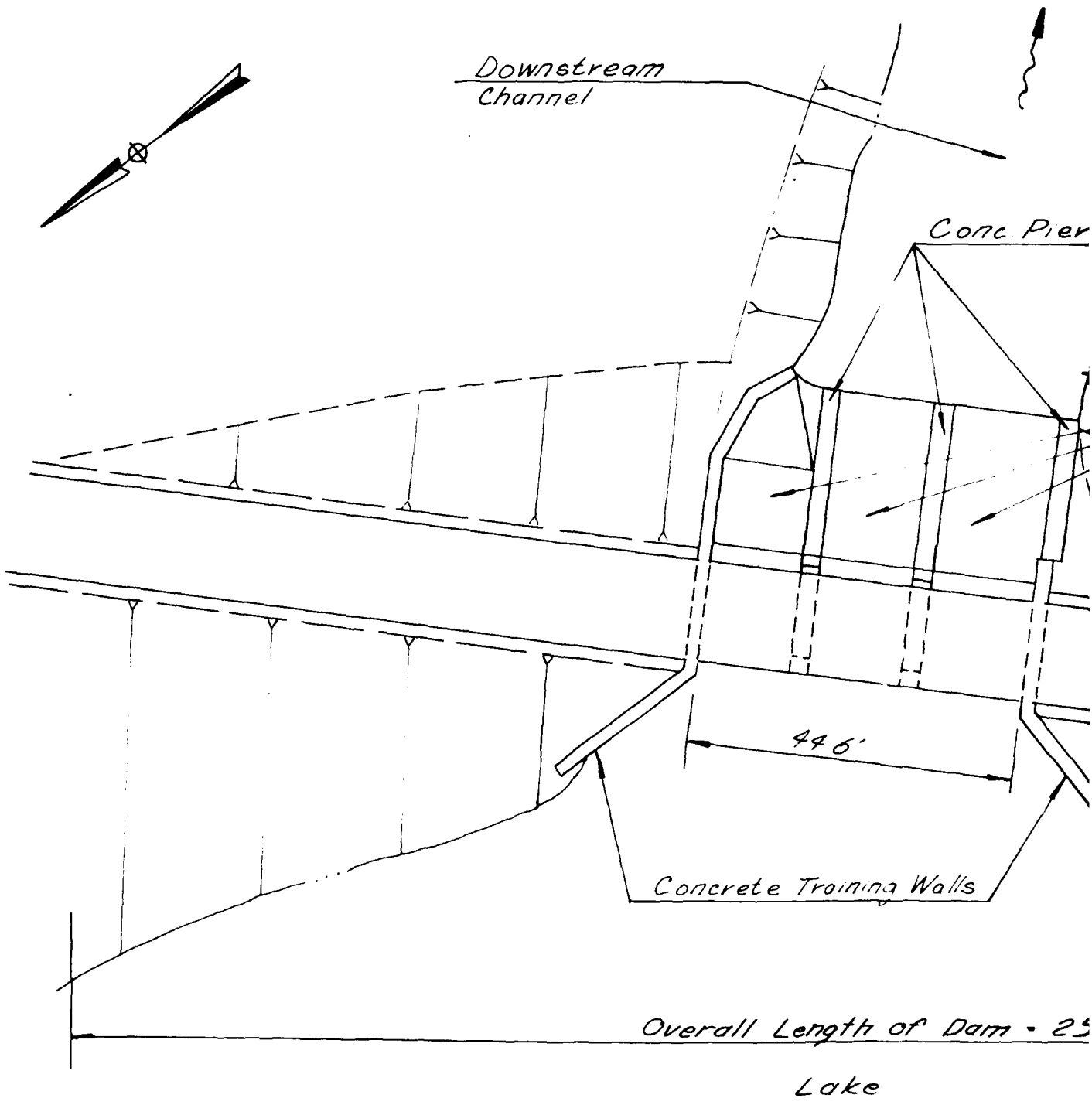


Legend

AR	Recent Alluvium Composed of stratified materials deposited by streams.
GM-4	Glacial ground moraine composed of silts and silty sands deposited during the Wisconsin glaciation.
NOTE:	Information taken from Rutgers University Soil Survey of New Jersey, Report No. 5, Union County, and Geologic Map of New Jersey prepared by Lewis and Kummel.

PLATE 3

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS SOIL MAP SHACKAMAXON DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. NJ00369 — SCALE: NONE DATE: NOV., 1979



Note:
Information taken froms plans by
Luster & Luster, Inc. dated Dec. 11, 1972
and field inspection November 15, 1979

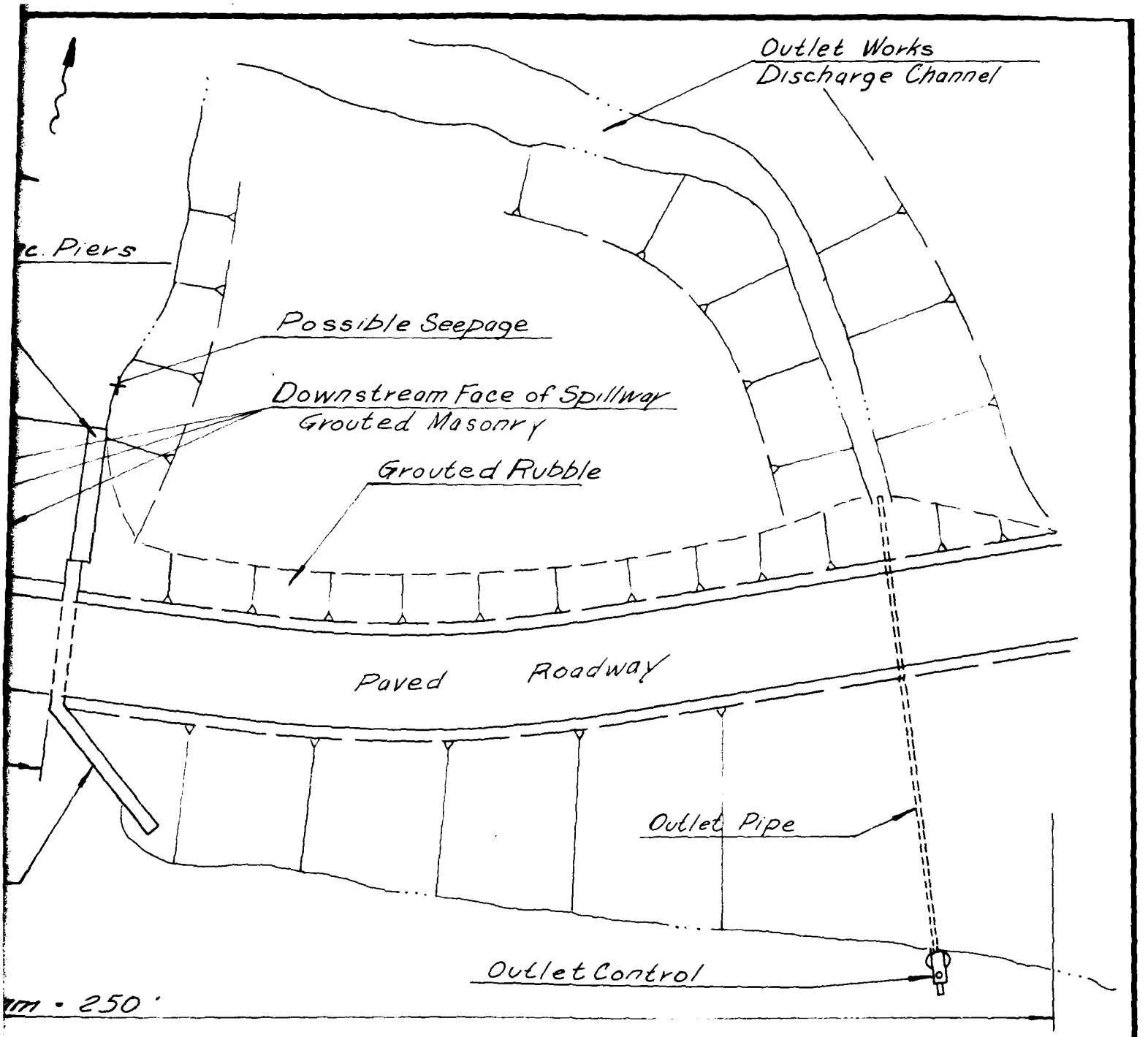


PLATE 4

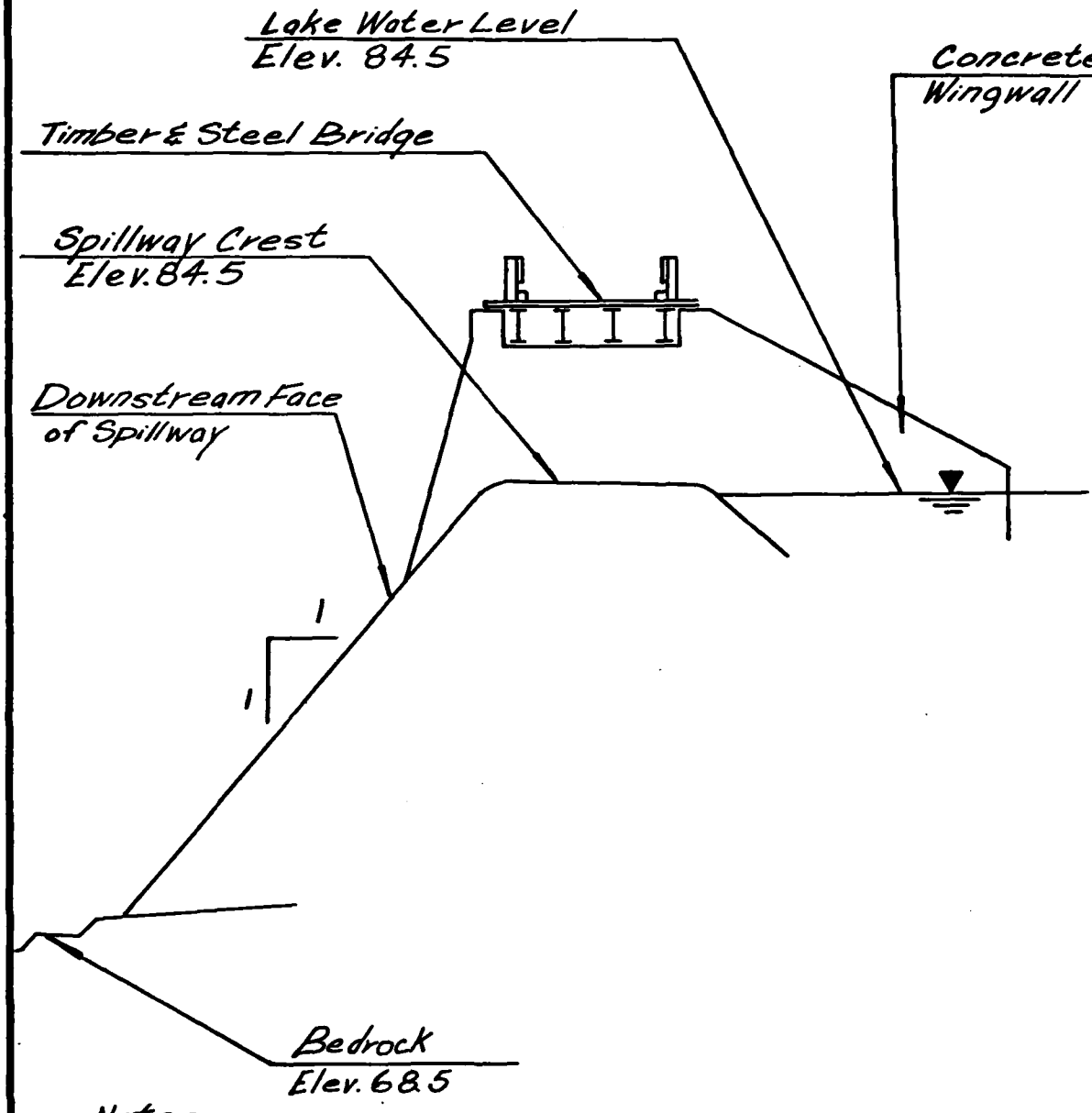
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

GENERAL PLAN

SHACKAMAXON DAM

I.D. N.J. 00369	SCALE: NOT TO SCALE
	DATE: DEC. 1979

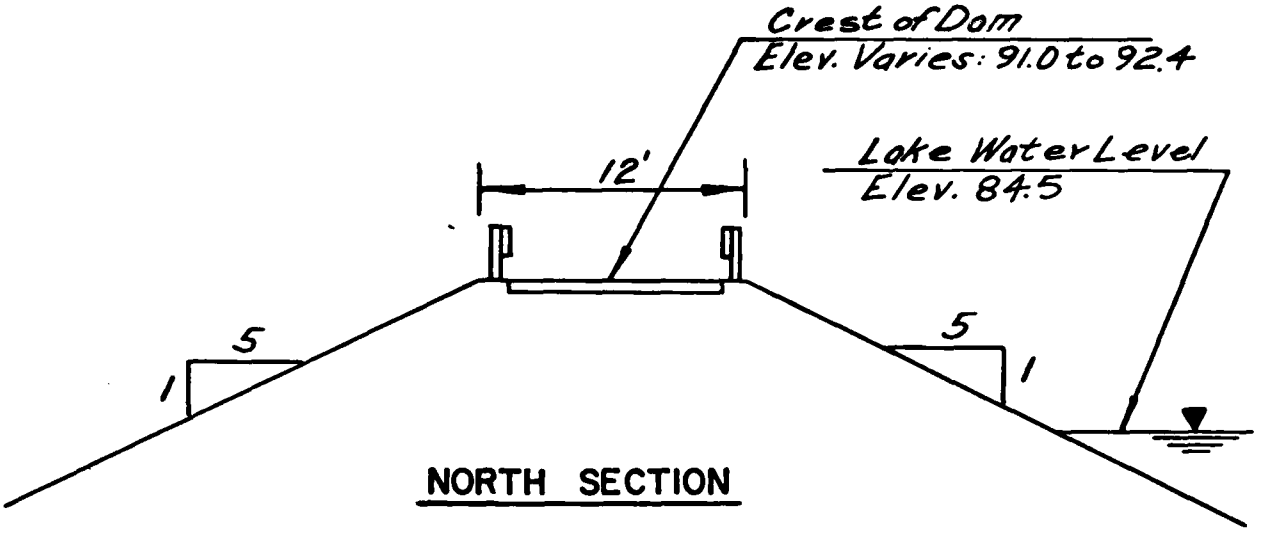


Notes:

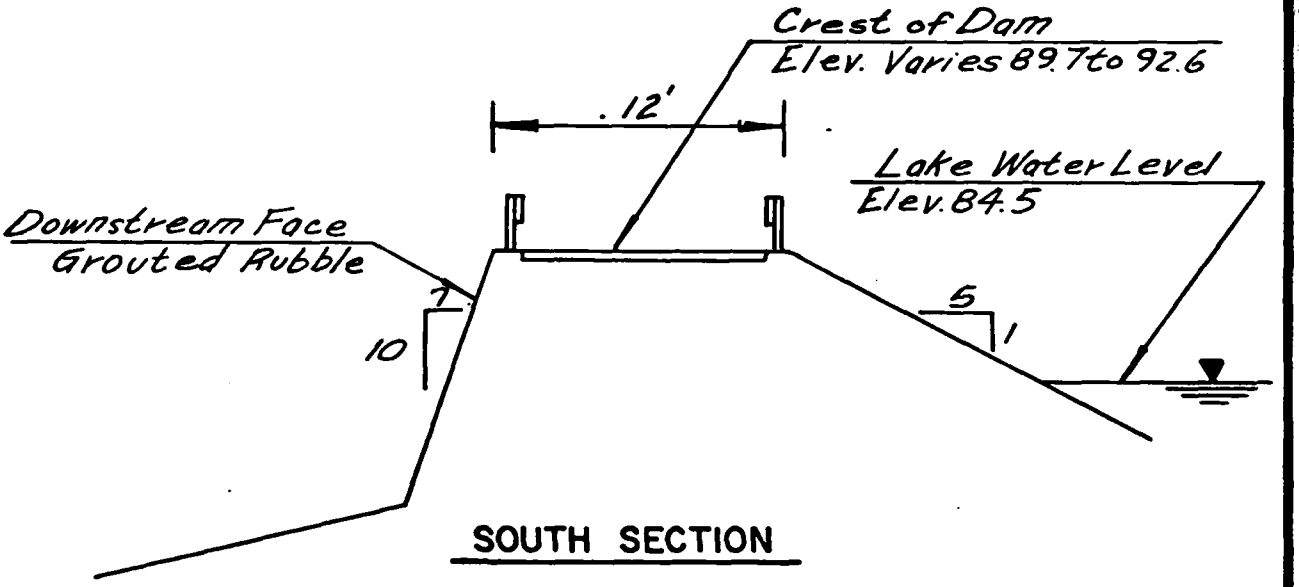
1. Information taken from plans by Luster & Luster, Inc. dated Dec. 11, 1972 and field inspected Nov. 15, 1979
2. Elevations based on N.G.V.D. taken from plans by Luster & Luster, Inc.

PLATE 5

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS SPILLWAY SECTION SHACKAMAXON DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00369 | SCALE: NOT TO SCALE DATE: DEC., 1979



NORTH SECTION



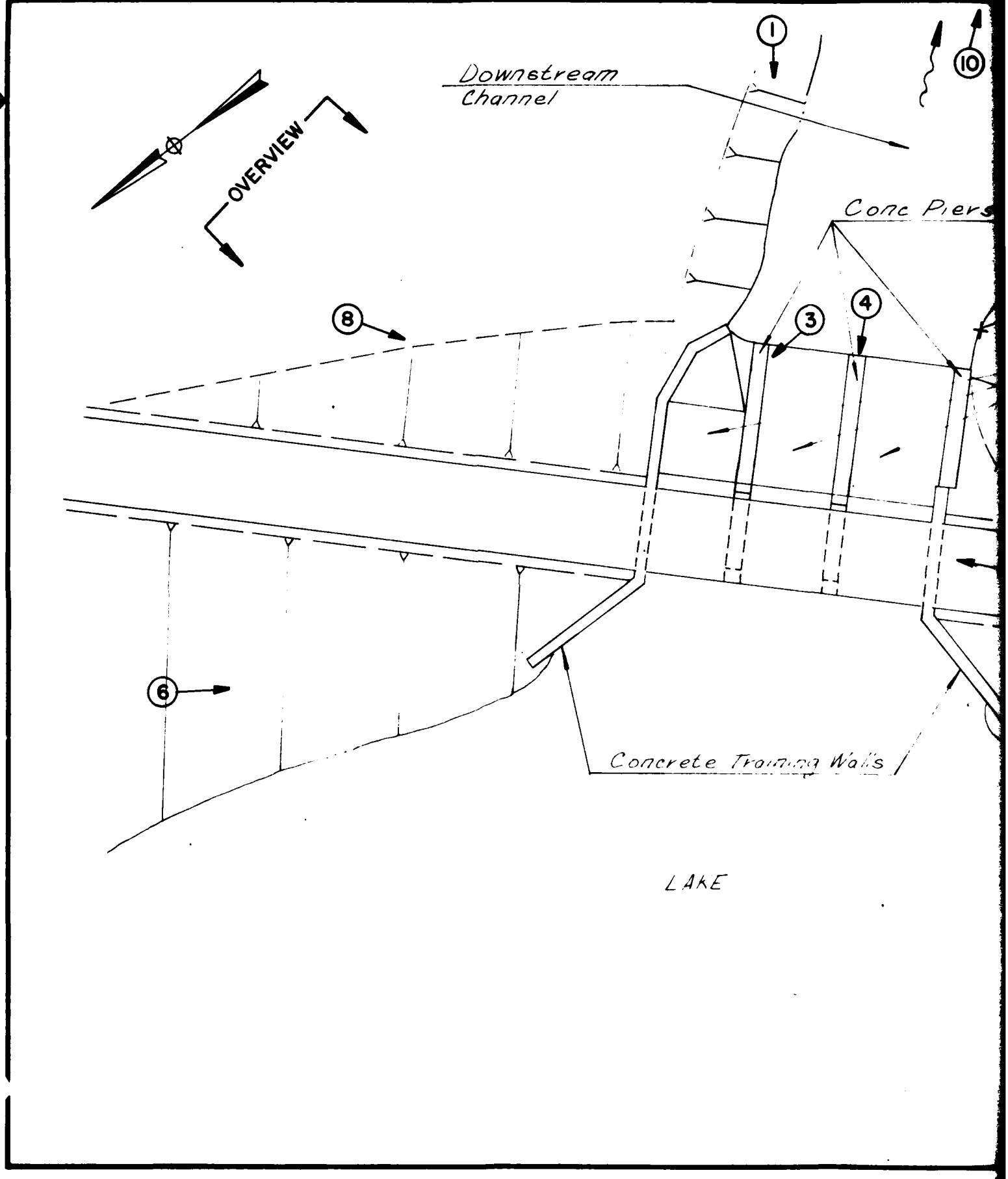
SOUTH SECTION

Notes:

1. Information taken from plans by Luster & Luster, Inc. dated Dec. 11, 1972 and field inspection November 15, 1979
2. Elevations based on N.G.V.D. taken from plans by Luster & Luster, Inc.

PLATE 6

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS DAM SECTION SHACKAMAXON DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D.N.J. 00369 — SCALE: NOT TO SCALE DATE: DEC., 1979


OVERVIEW
Downstream
Channel
1
10
Conc Piers
8
3
4
6
Concrete Training Walls
LAKE

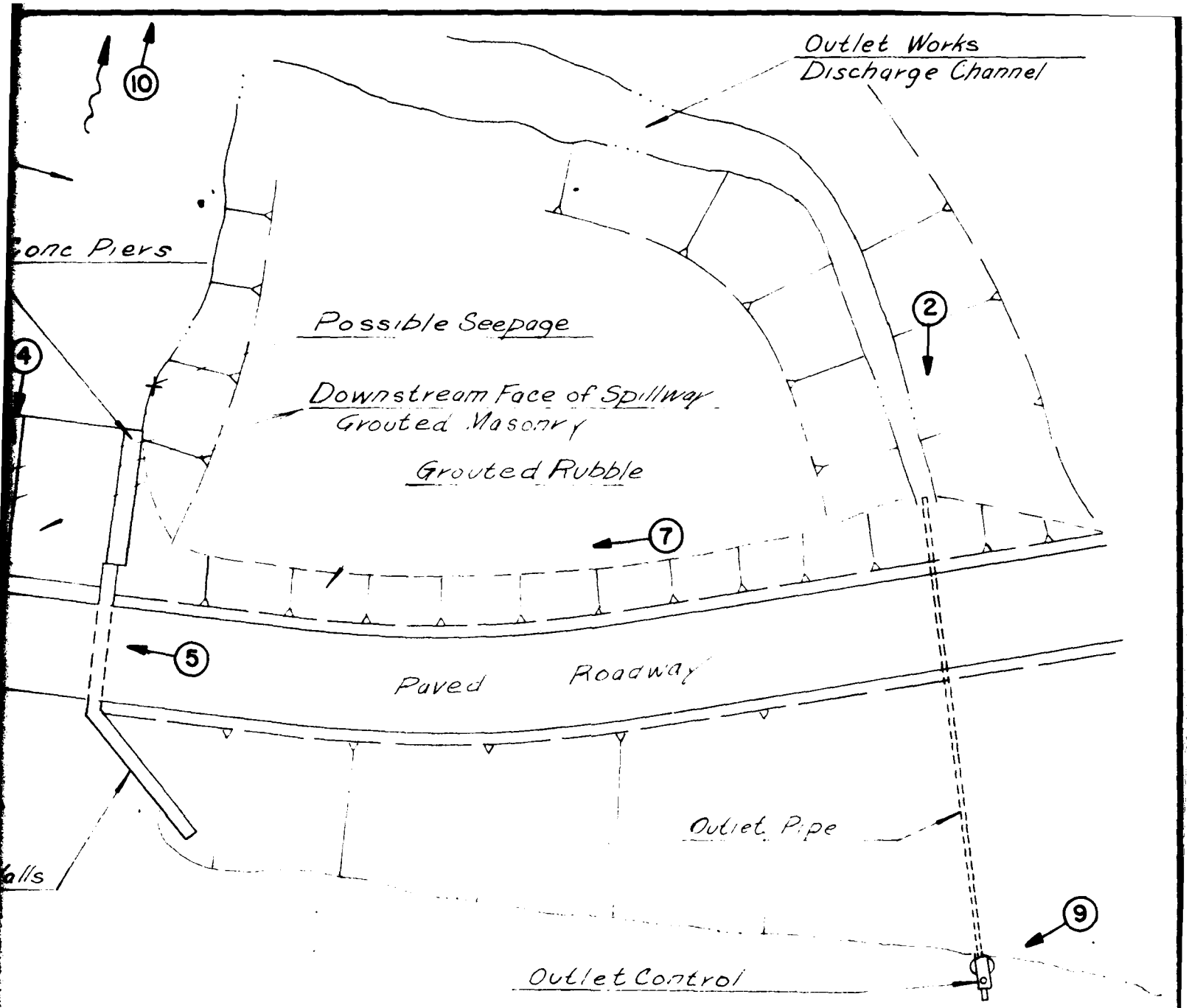


PLATE 7

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

PHOTO LOCATION PLAN

SHACKAMAXON DAM

I D N J. 00369	SCALE NOT TO SCALE
	DATE DEC. 1979

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List
Visual Inspection
Phase I

Name of Dam Shackamaxon Dam County Union State New Jersey Coordinators NJDEP

Date(s) Inspection 11/15/79 Weather Sunny Temperature 45°F

Pool Elevation at Time of Inspection 84.5 M.S.L. Tailwater at Time of Inspection 68.5 M.S.L.

Inspection Personnel:

John Gribbin Alan Volle

Ronald Lai Thomas Miller

Richard McDermott

J. Gribbin Recorder

Present: Bob McKenna, Maintenance Staff, Shackamaxon Golf and Country Club

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Embankment generally grass covered with a few trees and some weeds. Paved road on crest in good condition Rubble consisting of rocks and large pieces of concrete noted at toe adjacent to right side of downstream channel.	Recommend removal of rubble.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Junction of embankment and spillway training walls appeared satisfactory.	
ANY NOTICEABLE SEEPAGE	Discharge was noted at the toe adjacent to the right side of the downstream channel. Flow was less than 1 gal./min. The discharge could have originated in a toe drain.	Recommend further observation.
STAFF GAGE AND RECORDER	None observed.	
DRAINS	Apparent discharge from a toe drain was observed. (See "Seepage" above.)	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical: bridge over spillway is high point of dam; embankment slopes down to each end. Horizontal: generally straight.	
RIPRAP FAILURES	No riprap observed; no remains of riprap observed.	Construction drawings show riprap on upstream face.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	Outlet conduit not observed - submerged and below grade.	
INTAKE STRUCTURE	N.A.	
OUTLET STRUCTURE	N.A.	
OUTLET CHANNEL	Earth lined ditch - sides eroded with roots of small trees exposed.	
GATE AND GATE HOUSING	Gate operating stem appeared to be in satisfactory condition - not operated at time of inspection.	

SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
WEIR	Concrete weir with trapezoidal section. Concrete surface appeared rough, irregular and of substandard quality workmanship.	
TRAINING WALLS	Training walls, which also serve as bridge abutments appeared to be in good condition and of satisfactory workmanship.	
DOWNSTREAM FACE	Surface formed from grouted cobbles laid flush with existing concrete piers - appeared to be rough, irregular and of substandard workmanship. Exposed steel at toe could be reinforcing rods.	
DISCHARGE CHANNEL	Spillway discharges directly into downstream channel.	
BRIDGE	Steel beams, timber roadway and timber guide rail appeared to be in good condition.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	Concrete notched weir in downstream channel approx. 250 feet from dam. Concrete surfaces appeared to be in good condition.	
PIEZOMETERS	None	
OTHER	N.A.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Shore slopes vary from 2:1 to 5:1. Shores are generally grassed.	
SEDIMENTATION	Soundings in the lake in the vicinity of the dam indicate the presence of significant accumulation of sediment.	
STRUCTURES ALONG BANKS	Club house for golf course located at upstream end of reservoir.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Natural, well defined stream with no significant obstructions.	
SLOPES	Banks generally grassed with a few trees. Average slope of banks is 4:1.	
STRUCTURES ALONG BANKS	Two foot bridges over channel within 400 feet from dam. Dwelling located 600 feet from dam (120 feet from channel). Road bridge 1100 feet from dam.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
DAM - PLAN	Plan for reconstruction of dam titled "Shackamaxon Dam, Robinson's Branch of The Rahway River Stream" prepared by Luster and Luster, Inc. Dated Dec. 11, 1972 (5 sheets)
SECTIONS	
SPILLWAY - PLAN	Luster and Luster, Inc. (See above)
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Not available
OUTLETS - PLAN	Not available
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	
HYDRAULIC/HYDROLOGIC DATA	Available in report prepared by Terratech Engineers, Inc., October 1970.
RAINFALL/RESERVOIR RECORDS	Hydrograph of 1968 storm available in Terratech report.
CONSTRUCTION HISTORY	Brief records and correspondence can be found in NJDEP file.
LOCATION MAP	Available in NJDEP file.

ITEM	REMARKS
DESIGN REPORTS	Design report for repairs, titled "Report to the Board of Trustees, Shackamaxon Country Club, Hydraulic and Structural Analysis, Shackamaxon Country Club Lake and Dam," Terratech Engineers, Inc., October 1970.
GEOLOGY REPORTS	Terratech Report, October 1970
DESIGN COMPUTATIONS	
HYDROLOGY & HYDRAULICS	Terratech Report, October 1970
DAM STABILITY	Terratech Report, October 1970
SEEPAGE STUDIES	Terratech Report, October 1970
MATERIALS INVESTIGATIONS	
BORING RECORDS	Terratech Report, October 1970
LABORATORY	
FIELD	
POST-CONSTRUCTION SURVEYS OF DAM	Topographic survey performed in connection with 1970 repair design.
BORROW SOURCES	Unknown

ITEM	REMARKS
MONITORING SYSTEMS	Plan of "V" notch weirs to monitor inflow and outflow by Van Cleef Engineering Associates is available in NJDEP files. (1 sheet) titled "Weir Details" 11/5/75
MODIFICATIONS	Not available
HIGH POOL RECORDS	Not Available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Terratech design report for repairs to dam, October 1970.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Inspection reports by State of New Jersey in 1951 and 1971 in NJDEP files contain brief descriptions of accidents in 1951, 1968 and 1971.
MAINTENANCE OPERATION RECORDS	Limited maintenance records are available in NJDEP files. Also, lake water elevation records during 1972, 1973 used to document the maintenance of a partially drawn down lake pending repairs to the dam.

APPENDIX 2

Photographs

PHOTO 1

SPILLWAY

PHOTO 2

OUTLET WORKS DISCHARGE IN DOWNSTREAM FACE OF DAM

SHACKAMAXON DAM
15 NOVEMBER 1979

PHOTO 3

DOWNSTREAM FACE OF SPILLWAY

PHOTO 4

POOR CONDITION OF DOWNSTREAM FACE OF SPILLWAY AT TOE

SHACKAMAXON DAM
15 NOVEMBER 1979

PHOTO 5

CREST OF DAM

PHOTO 6

UPSTREAM FACE OF DAM

SHACKAMAXON DAM
15 NOVEMBER 1979

PHOTO 7

DOWNSTREAM FACE OF DAM - SOUTH SECTION

PHOTO 8

DOWNSTREAM FACE OF DAM - NORTH SECTION

SHACKAMAXON DAM
15 NOVEMBER 1979

PHOTO 9

OUTLET CONTROL

PHOTO 10

DOWNSTREAM CHANNEL

SHACKAMAXON DAM
15 NOVEMBER 1979

APPENDIX 3

Engineering Data

CHECK LIST

HYDROLOGIC AND HYDRAULIC DATA

ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Golf course and residential area

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 84.5 (53 Acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N.A.

ELEVATION MAXIMUM DESIGN POOL: 91.4

ELEVATION TOP DAM: 89.7

SPILLWAY CREST: Straight masonry weir

a. Elevation 84.5
b. Type Free overflow
c. Width 12 feet
d. Length 40.5 feet
e. Location Spillover Center of dam
f. Number and Type of Gates None

OUTLET WORKS:

a. Type 15" RCP with lift gate
b. Location Southwest end of embankment
c. Entrance inverts 79.5
d. Exit inverts 77.7
e. Emergency draindown facilities: Lift gate at upstream end

HYDROMETEOROLOGICAL GAGES: N.A.

a. Type N.A.
b. Location N.A.
c. Records N.A.

MAXIMUM NON-DAMAGING DISCHARGE:

(Lake stage equal to top of dam) 1290 c.f.s.

APPENDIX 4

Hydraulic/Hydrologic Computations

HYDROLOGY

Hydrologic Analysis

Runoff hydrograph will be developed by HEC-1-DB using triangular hydrograph with curvilinear transformation.

Drainage area = 2.5 sq. Miles

Infiltration Data

Initial infiltration	1.0 in
Constant infiltration	0.1 in/hr.

Time of Concentration (1)

Vel. of overland flow by chart from SCS TR-55

Distance of overland flow 6,000 feet at 1.6 %

Distance of channel flow 11,000 feet at 0.7 %

$$Tc = \left(\frac{6000}{0.9} + \frac{11,000}{1.3}\right)\frac{1}{3600}$$

$$= \underline{\underline{4.2 \text{ hr}}}$$

Time of Concentration (2)

by Kirpich Pg 14-7 "Handbook of Applied Hydrology" Chow Ed. McGraw Hill

$$T_c = 0.00013 \frac{L^{0.77}}{S^{0.385}}$$

T_c = Time of concentration in hours
L = Distance in feet from outflow point to basin divide
S = Average slope in ft/ft

$$T_c = 0.00013 \frac{(17000)^{0.77}}{(0.01)^{0.385}}$$

$$= \underline{1.38} \text{ hrs}$$

Time of Concentration (3)

Lag time by Snyders Method

$$t_L = C_t (L L_{ca})^{0.3}$$

$C_t = 2.0$
$L = 17000$ ft
$L_{ca} = 8000$ ft

$t_L = \underline{3.2}$ hr.

Time of Concentration (4)

by Kerby Pg 14-36 "Handbook of Applied Hydrology" Chow Ed. McGraw Hill

$$t_c^{2.14} = \frac{2}{3}\frac{Ln}{\sqrt{s}}$$ For overland flow

t_c = time of concentration in minutes
L = length of overland flow in feet
s = slope ft/ft
n = 0.4 roughness coef.

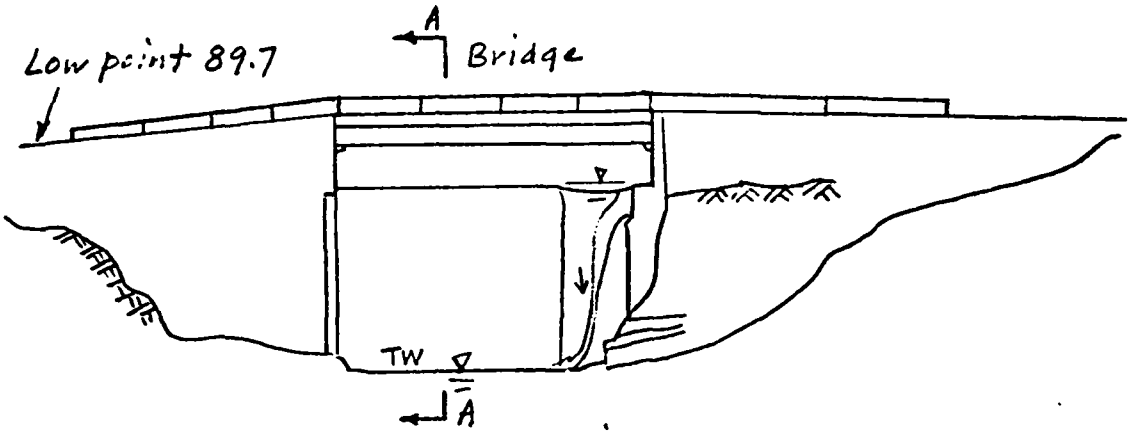
$$t_c^{2.14} = \frac{2}{3}\frac{6000\ (0.4)}{\sqrt{0.016}}$$

t_c = 82.6 min
= 1.4 hr.

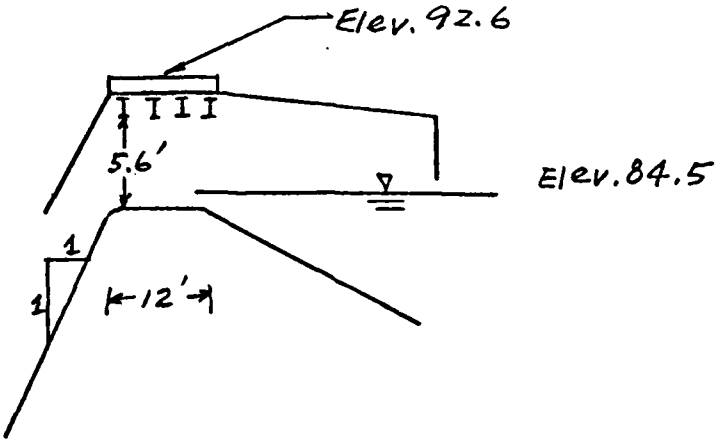
T_c = 1.4 + 2.4
= 3.8 hrs

Use T_c = 3.8 hr lag = 2.3 hr.

HYDRAULICS



Front Elevation



AA

SECTION OF SPILLWAY

$Q = C L H^{3/2}$

C values Pg 5-40
" Handbook of Hydraulics"
King et. al.

Length of spillway 40 feet

$C = 2.63$

STAGE DISCHARGE TABULATION

W.L. (ft)	H (ft)	$H^{3/2}$	L (ft)	C	Q (cfs)	Q (orifice)
84.5	0	0	40	2.63	0	—
85.5	1	1	40	2.63	105	—
86.5	2	2.8	40	2.63	295	—
87.5	3	5.2	40	2.63	547	—
88.5	4	8	40	2.63	842	—
89.5	5	11.2	40	2.63	1178	—
90.5	6	14.7	40	2.63	~~1546~~	1736
91.5	7	18.5	40	2.63	~~1946~~	1989
92.5	8	22.6	40	2.63	~~2378~~	2214

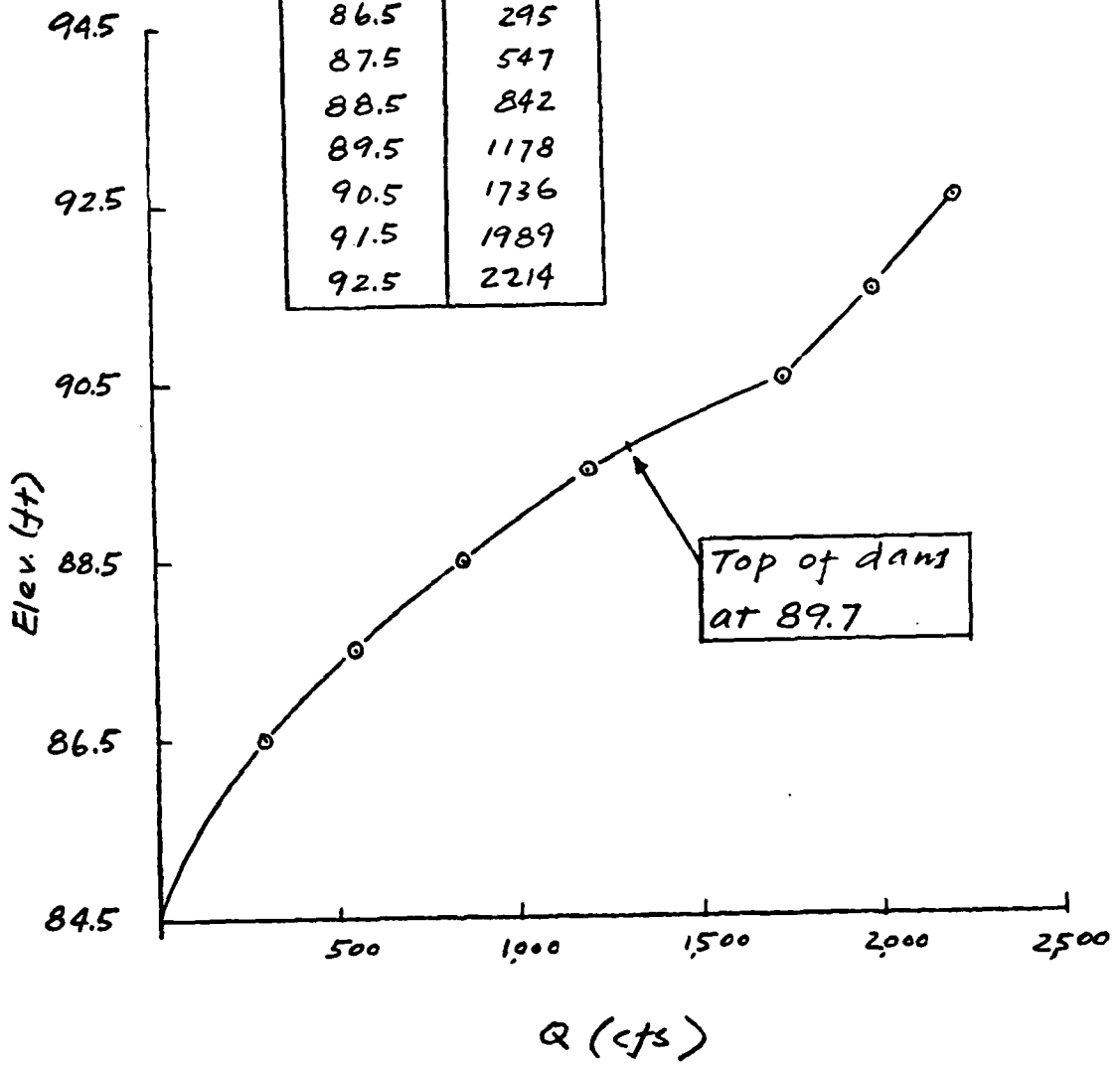
Orifice $Q = 0.54 A \sqrt{2gh}$ Pg 411 "Handbook of Hydraulics" King

$A = 40 \times 5.6 = 224\ ft^2$

$h = H - 2.8'$

STAGE DISCHARGE CURVE

W.L. (ft)	Q (cfs)
84.5	0
85.5	105
86.5	295
87.5	547
88.5	842
89.5	1178
90.5	1736
91.5	1989
92.5	2214



Lake Storage Volume

Elev MSL	Surface Area (Ac)
70	0
84.5	11.0
90	16.5
100	92.0

HEC-1-DB will convert area to storage in Ac-ft.

Outlet Works

From N.J.D.E.P. file outlet pipe 15" RCP

From field measurement inlet 5' below water surface

During drawdown both ends will be submerged, outlet control from Chart 9 "Hydraulic Charts for The Selection of Highway Culverts" USDOT

H = 5 ft ±
L = 60' ±

Q = 14 cfs Inflow = 3cfs ±

Average discharge 14/2 = 7 cfs

Drawdown time

$$\frac{53 \times 43560}{(7-3) \times 3600} = 160 \text{ hours}$$

$$= \underline{6.7} \text{ days}$$

Inflow approximated by 1 cfs / sq mi

STORCH ENGINEERS

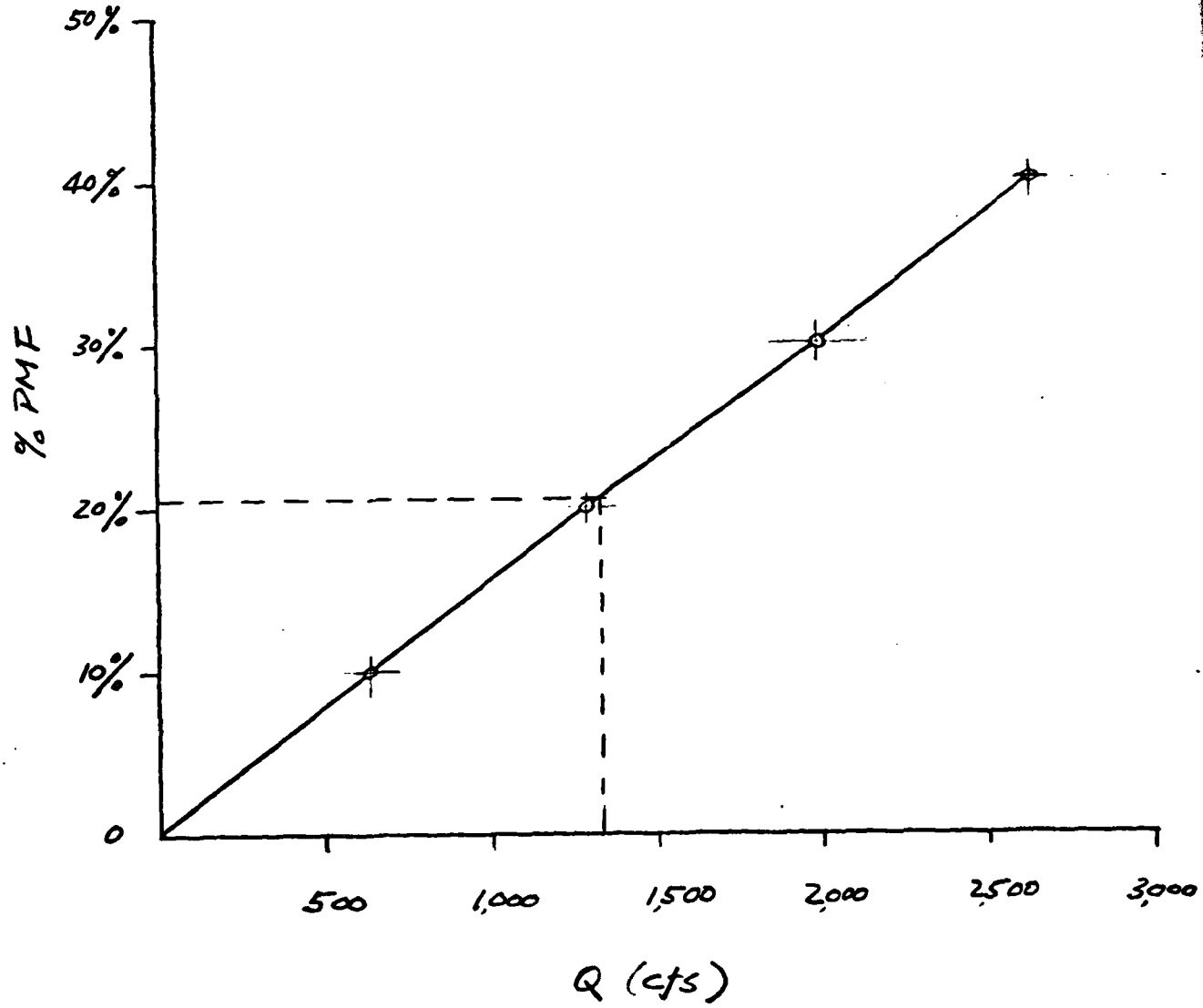
Sheet 9 of 9

Project Shackamaxon Dam 1132C

Made By RL Date 1-21-80

Chkd By JG Date 1/25/80

Overtopping Potential



Dam can pass 20.5% of PMF
or 41 % of SDF

HEC-1-DB COMPUTATIONS

```
A1                              NATIONAL DAM SAFETY PROGRAM
A2                              SHACKAMAXON DAM   NEW JERSEY
A3                              MULTI RATIO ROUTING
B     150                     10                                                                3
B1      5
J       1         5            1
J1    0.5       0.4          0.3       0.2       0.1
K              LAKE                                                 1
K1                              SUBAREA INFLOW HYDROGRAPH TO SHACKAMAXON DAM
M       1         2          2.5                 2.5                                            1
P              25.8          100       109       117
T                                                                   1       0.1
W2              2.3
X    -1.0     -0.05          2.0
K       1       DAM                                                 1
K1                              ROUTE DISCHARGE THRU DAM
Y                                        1         1
Y1      1                                                       -84.5        -1
Y4   84.5      85.5         86.5      87.5      88.5      89.5   90.5      91.5      92.5
Y5      0       105          295       547       842      1178   1736      1989      2214
$A      0        11         16.5        92
$E     70      84.5           90       100
$$   84.5
$D   89.7      2.63          1.5       235
K      99
A
A
A
A
A
```

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

 RUN  DATE= 80/01/17.
      TIME= 12.27.08.

                                NATIONAL DAM SAFETY PROGRAM
                                SHACKAMAXON DAM    NEW JERSEY
                                MULTI RATIO ROUTING

                                      JOB SPECIFICATION
      NQ      NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
     150       0       10        0       0        0        0        0        3        0
                                JOPER      NW     LROPT    TRACE
                                    5       0        0        0

                                MULTI-PLAN ANALYSES TO BE PERFORMED
                                      NPLAN= 1 NRTIO= 5 LRTIO= 1
                        RTIOS=    .50     .40     .30     .20     .10

**********      **********      **********      **********      **********
                                SUB-AREA RUNOFF COMPUTATION
                                SUBAREA INFLOW HYDROGRAPH TO SHACKAMAXON DAM
      ISTAQ   ICOMP   IECON   ITAPE   JPLT    JPRT   INAME  ISTAGE  IAUTO
      LAKE        0       0       0      0       0       1       0      0
                                      HYDROGRAPH DATA
     IHYDG    IUNG     TAREA    SNAP    TRSDA    TRSPC    RATIO   ISNOW   ISAME   LOCAL
         1       2      2.50    0.00     2.50     0.00    0.000       0       1       0
                                      PRECIP DATA
      SPFE      PMS       R6      R12      R24      R48      R72      R96
      0.00    25.80   100.00   109.00   117.00     0.00     0.00     0.00
TRSPC COMPUTED BY THE PROGRAM IS  .800
                                      LOSS DATA
     LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         0    0.00    0.00    1.00    0.00    0.00    1.00    1.00     .10    0.00    0.00
                                UNIT HYDROGRAPH DATA
                                  TC=  0.00    LAG=  2.30
                                RECESSION DATA
                                STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 2.00
     UNIT HYDROGRAPH 71 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=   2.30  VOL= 1.00
   11.    29.    55.    87.   126.   173.   230.   295.   358.   415.
  454.   483.   502.   505.   504.   496.   474.   450.   424.   396.
  360.   321.   279.   244.   216.   192.   171.   152.   137.   124.
  111.    99.    88.    78.    70.    63.    55.    50.    45.    39.
   35.    31.    28.    25.    22.    20.    18.    16.    14.    13.
   11.    10.     9.     8.     7.     6.     6.     5.     5.     4.
    4.     4.     3.     3.     2.     2.     2.     1.     1.     1.
    0.
```

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.02	0.00	.02	2.
1.01	.20	2	.02	0.00	.02	2.
1.01	.30	3	.02	0.00	.02	2.
1.01	.40	4	.02	0.00	.02	2.
1.01	.50	5	.02	0.00	.02	2.
1.01	1.00	6	.02	0.00	.02	2.
1.01	1.10	7	.02	0.00	.02	2.
1.01	1.20	8	.02	0.00	.02	1.
1.01	1.30	9	.02	0.00	.02	1.
1.01	1.40	10	.02	0.00	.02	1.
1.01	1.50	11	.02	0.00	.02	1.
1.01	2.00	12	.02	0.00	.02	1.
1.01	2.10	13	.02	0.00	.02	1.
1.01	2.20	14	.02	0.00	.02	1.
1.01	2.30	15	.02	0.00	.02	1.
1.01	2.40	16	.02	0.00	.02	1.
1.01	2.50	17	.02	0.00	.02	1.
1.01	3.00	18	.02	0.00	.02	1.
1.01	3.10	19	.02	0.00	.02	1.
1.01	3.20	20	.02	0.00	.02	1.
1.01	3.30	21	.02	0.00	.02	1.
1.01	3.40	22	.02	0.00	.02	1.
1.01	3.50	23	.02	0.00	.02	1.
1.01	4.00	24	.02	0.00	.02	0.
1.01	4.10	25	.02	0.00	.02	0.
1.01	4.20	26	.02	0.00	.02	0.
1.01	4.30	27	.02	0.00	.02	0.
1.01	4.40	28	.02	0.00	.02	0.
1.01	4.50	29	.02	0.00	.02	0.
1.01	5.00	30	.02	0.00	.02	0.
1.01	5.10	31	.02	0.00	.02	0.
1.01	5.20	32	.02	0.00	.02	0.
1.01	5.30	33	.02	0.00	.02	0.
1.01	5.40	34	.02	0.00	.02	0.
1.01	5.50	35	.02	0.00	.02	0.
1.01	6.00	36	.02	0.00	.02	0.
1.01	6.10	37	.05	0.00	.05	0.
1.01	6.20	38	.05	0.00	.05	0.
1.01	6.30	39	.05	0.00	.05	0.
1.01	6.40	40	.05	0.00	.05	0.
1.01	6.50	41	.05	0.00	.05	0.
1.01	7.00	42	.05	0.00	.05	0.
1.01	7.10	43	.05	.01	.04	0.
1.01	7.20	44	.05	.03	.02	1.
1.01	7.30	45	.05	.03	.02	2.
1.01	7.40	46	.05	.03	.02	5.
1.01	7.50	47	.05	.03	.02	8.
1.01	8.00	48	.05	.03	.02	13.
1.01	8.10	49	.05	.03	.02	20.
1.01	8.20	50	.05	.03	.02	29.
1.01	8.30	51	.05	.03	.02	40.
1.01	8.40	52	.05	.03	.02	54.
1.01	8.50	53	.05	.03	.02	69.
1.01	9.00	54	.05	.03	.02	85.
1.01	9.10	55	.05	.03	.02	102.
1.01	9.20	56	.05	.03	.02	120.
1.01	9.30	57	.05	.03	.02	137.
1.01	9.40	58	.05	.03	.02	155.
1.01	9.50	59	.05	.03	.02	172.
1.01	10.00	60	.05	.03	.02	188.
1.01	10.10	61	.05	.03	.02	204.
1.01	10.20	62	.05	.03	.02	218.
1.01	10.30	63	.05	.03	.02	231.
1.01	10.40	64	.05	.03	.02	243.
1.01	10.50	65	.05	.03	.02	254.
1.01	11.00	66	.05	.03	.02	263.
1.01	11.10	67	.05	.03	.02	271.
1.01	11.20	68	.05	.03	.02	278.
1.01	11.30	69	.05	.03	.02	285.
1.01	11.40	70	.05	.03	.02	290.
1.01	11.50	71	.05	.03	.02	296.
1.01	12.00	72	.05	.03	.02	300.
1.01	12.10	73	.34	.33	.02	307.
1.01	12.20	74	.34	.33	.02	320.
1.01	12.30	75	.34	.33	.02	339.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	12.40	76	.34	.33	.02	367.
1.01	12.50	77	.34	.33	.02	407.
1.01	13.00	78	.34	.33	.02	460.
1.01	13.10	79	.41	.40	.02	530.
1.01	13.20	80	.41	.40	.02	620.
1.01	13.30	81	.41	.40	.02	730.
1.01	13.40	82	.41	.40	.02	859.
1.01	13.50	83	.41	.40	.02	1001.
1.01	14.00	84	.41	.40	.02	1156.
1.01	14.10	85	.52	.50	.02	1320.
1.01	14.20	86	.52	.50	.02	1492.
1.01	14.30	87	.52	.50	.02	1671.
1.01	14.40	88	.52	.50	.02	1854.
1.01	14.50	89	.52	.50	.02	2038.
1.01	15.00	90	.52	.50	.02	2221.
1.01	15.10	91	.47	.45	.02	2403.
1.01	15.20	92	.78	.77	.02	2587.
1.01	15.30	93	1.41	1.40	.02	2777.
1.01	15.40	94	3.53	3.51	.02	3003.
1.01	15.50	95	1.02	1.00	.02	3256.
1.01	16.00	96	.63	.61	.02	3533.
1.01	16.10	97	.48	.46	.02	3834.
1.01	16.20	98	.48	.46	.02	4160.
1.01	16.30	99	.48	.46	.02	4514.
1.01	16.40	100	.48	.46	.02	4901.
1.01	16.50	101	.48	.46	.02	5306.
1.01	17.00	102	.48	.46	.02	5688.
1.01	17.10	103	.38	.36	.02	6022.
1.01	17.20	104	.38	.36	.02	6276.
1.01	17.30	105	.38	.36	.02	6465.
1.01	17.40	106	.38	.36	.02	6587.
1.01	17.50	107	.38	.36	.02	6638.
1.01	18.00	108	.38	.36	.02	6643.
1.01	18.10	109	.03	.01	.02	6595.
1.01	18.20	110	.03	.01	.02	6482.
1.01	18.30	111	.03	.01	.02	6331.
1.01	18.40	112	.03	.01	.02	6147.
1.01	18.50	113	.03	.01	.02	5927.
1.01	19.00	114	.03	.01	.02	5659.
1.01	19.10	115	.03	.01	.02	5351.
1.01	19.20	116	.03	.01	.02	5015.
1.01	19.30	117	.03	.01	.02	4681.
1.01	19.40	118	.03	.01	.02	4356.
1.01	19.50	119	.03	.01	.02	4049.
1.01	20.00	120	.03	.01	.02	3759.
1.01	20.10	121	.03	.01	.02	3489.
1.01	20.20	122	.03	.01	.02	3241.
1.01	20.30	123	.03	.01	.02	2867.
1.01	20.40	124	.03	.01	.02	2603.
1.01	20.50	125	.03	.01	.02	2356.
1.01	21.00	126	.03	.01	.02	2124.
1.01	21.10	127	.03	.01	.02	1908.
1.01	21.20	128	.03	.01	.02	1712.
1.01	21.30	129	.03	.01	.02	1535.
1.01	21.40	130	.03	.01	.02	1376.
1.01	21.50	131	.03	.01	.02	1238.
1.01	22.00	132	.03	.01	.02	1116.
1.01	22.10	133	.03	.01	.02	1006.
1.01	22.20	134	.03	.01	.02	910.
1.01	22.30	135	.03	.01	.02	824.
1.01	22.40	136	.03	.01	.02	747.
1.01	22.50	137	.03	.01	.02	679.
1.01	23.00	138	.03	.01	.02	617.
1.01	23.10	139	.03	.01	.02	562.
1.01	23.20	140	.03	.01	.02	513.
1.01	23.30	141	.03	.01	.02	468.
1.01	23.40	142	.03	.01	.02	429.
1.01	23.50	143	.03	.01	.02	394.
1.02	0.00	144	.03	.01	.02	363.
1.02	.10	145	0.00	0.00	0.00	334.
1.02	.20	146	0.00	0.00	0.00	312.
1.02	.30	147	0.00	0.00	0.00	291.
1.02	.40	148	0.00	0.00	0.00	272.
1.02	.50	149	0.00	0.00	0.00	253.
1.02	1.00	150	0.00	0.00	0.00	236.
		SUM	24.15	21.46	2.69	205577.
			(613.)	(545.)	(68.)	(5821.29)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6643.	4597.	1427.	1370.	205467.
CMS	188.	130.	40.	39.	5818.
INCHES		17.10	21.24	21.24	21.24
MM		434.43	539.39	539.42	539.42
AC-FT		2279.	2830.	2830.	2830.
THOUS CU M		2811.	3491.	3491.	3491.

HYDROGRAPH AT STA LAKE FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3322.	2298.	713.	685.	102733.
CMS	94.	65.	20.	19.	2909.
INCHES		8.55	10.62	10.62	10.62
MM		217.22	269.70	269.71	269.71
AC-FT		1140.	1415.	1415.	1415.
THOUS CU M		1406.	1745.	1745.	1745.

STATION DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	1.	1.	2.	3.
5.	7.	10.	14.	18.	22.	27.	33.	39.	45.
51.	58.	64.	70.	77.	83.	89.	94.	100.	105.
113.	120.	126.	132.	138.	146.	155.	167.	183.	203.
228.	260.	299.	356.	417.	482.	552.	635.	719.	804.
894.	987.	1079.	1173.	1327.	1535.	1728.	1904.	2080.	2251.
2425.	2615.	2800.	2964.	3097.	3197.	3262.	3297.	3304.	3284.
3236.	3167.	3078.	2969.	2840.	2692.	2534.	2373.	2215.	2039.
1874.	1724.	1584.	1454.	1337.	1245.	1162.	1096.	1023.	945.
868.	798.	733.	670.	611.	555.	510.	468.	428.	392.
357.	326.	298.	277.	258.	240.	223.	207.	193.	179.

STORAGE

53.	53.	53.	53.	53.	53.	53.	53.	53.	53.
53.	53.	53.	53.	53.	53.	53.	53.	53.	53.
53.	53.	53.	53.	53.	53.	53.	53.	53.	53.
53.	53.	53.	53.	53.	53.	53.	53.	53.	53.
53.	53.	53.	53.	53.	53.	53.	53.	53.	54.
54.	54.	54.	55.	55.	56.	56.	57.	57.	58.
59.	59.	60.	61.	61.	62.	63.	63.	64.	65.
65.	66.	66.	66.	67.	67.	68.	69.	70.	71.
73.	75.	77.	80.	83.	87.	91.	95.	99.	103.
107.	111.	116.	120.	124.	128.	131.	133.	136.	138.
141.	144.	147.	150.	152.	154.	155.	155.	156.	155.
155.	153.	152.	150.	148.	146.	143.	140.	138.	135.
133.	131.	129.	127.	124.	122.	119.	116.	113.	109.
106.	103.	99.	96.	93.	91.	88.	86.	84.	82.
80.	79.	77.	76.	75.	73.	72.	71.	70.	69.

STAGE

84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5
84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5
84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5
84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5
84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5
84.5	84.6	84.6	84.6	84.7	84.7	84.8	84.8	84.9	84.9
85.0	85.0	85.1	85.2	85.2	85.3	85.3	85.4	85.4	85.5
85.5	85.6	85.6	85.6	85.7	85.7	85.8	85.8	85.9	86.0
86.1	86.3	86.5	86.7	87.0	87.2	87.5	87.8	88.1	88.4
88.7	88.9	89.2	89.5	89.8	90.0	90.2	90.3	90.4	90.6
90.7	90.9	91.0	91.1	91.2	91.3	91.4	91.4	91.4	91.4
91.3	91.3	91.2	91.1	91.0	90.9	90.8	90.7	90.5	90.4
90.3	90.1	90.0	89.9	89.8	89.6	89.5	89.3	89.0	88.8
88.6	88.4	88.1	87.9	87.7	87.5	87.4	87.2	87.0	86.9
86.7	86.6	86.5	86.4	86.3	86.2	86.1	86.0	86.0	85.9

PEAK OUTFLOW IS 3304. AT TIME 18.17 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3304.	2275.	705.	677.	101557.
CMS	94.	64.	20.	19.	2876.
INCHES		8.47	10.50	10.50	10.50
MM		215.04	266.62	266.62	266.62
AC-FT		1128.	1399.	1399.	1399.
THOUS CU M		1392.	1725.	1725.	1725.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE DISCHARGE THRU DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-85.	-1

STAGE	84.50	85.50	86.50	87.50	88.50	89.50	90.50	91.50	92.50
FLOW	0.00	105.00	295.00	547.00	842.00	1178.00	1736.00	1989.00	2214.00
SURFACE AREA=	0.	11.	17.	92.					
CAPACITY=	0.	53.	128.	620.					
ELEVATION=	70.	85.	90.	100.					

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
84.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
89.7	2.6	1.5	235.

SUMMARY OF DAM SAFETY ANALYSIS

•••••••••		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	84.50	84.50	89.70
	STORAGE	53.	53.	123.
	OUTFLOW	0.	0.	1290.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	91.38	1.68	156.	3304.	5.17	18.17	0.00
.43	90.89	1.19	145.	2643.	4.33	18.17	0.00
.33	90.36	.66	134.	1985.	3.00	18.17	0.00
.20	89.78	0.00	123.	1290.	0.00	18.33	0.00
.10	87.79	0.00	94.	631.	0.00	18.50	0.00

DOWNSTREAM ROUTING
Dam Overtopping
(No Breach)

SUMMARY OF DAM SAFETY ANALYSIS

.....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	84.50	84.50	89.70
	STORAGE	53.	53.	123.
	OUTFLOW	0.	0.	1290.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	91.38	1.68	156.	3304.	5.17	18.17	0.00
.40	90.89	1.19	145.	2643.	4.33	18.17	0.00
.30	90.36	.66	134.	1985.	3.00	18.17	0.00
.20	89.70	0.00	123.	1290.	0.00	18.33	0.00
.10	87.79	0.00	94.	631.	0.00	18.50	0.00

PLAN 1 STATION 1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3305.	74.3	18.17
.40	2643.	73.7	18.17
.30	1985.	73.0	18.17
.20	1289.	72.1	18.33
.10	631.	71.0	18.50

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3305.	69.0	18.17
.40	2643.	68.6	18.17
.30	1985.	68.2	18.17
.20	1288.	67.7	18.33
.10	631.	67.0	18.50

DOWNSTREAM ROUTING
(Breach Condition)

SUMMARY OF DAM SAFETY ANALYSIS

.....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	84.50	84.50	89.70
	STORAGE	53.	53.	123.
	OUTFLOW	0.	0.	1290.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	90.57	.87	138.	7510.	1.17	17.10	16.67
.40	90.57	.87	138.	7234.	1.17	17.59	17.17
.30	90.36	.66	134.	1985.	3.00	18.17	0.00
.20	89.70	0.00	123.	1290.	0.00	18.33	0.00
.10	87.79	0.00	94.	631.	0.00	18.50	0.00

PLAN 1 STATION 1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	6978.	76.4	17.17
.40	6711.	76.2	17.50
.30	1985.	73.0	18.17
.20	1289.	72.1	18.33
.10	631.	71.0	18.50

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	7025.	70.4	17.17
.40	6645.	70.3	17.50
.30	1985.	68.2	18.17
.20	1288.	67.7	18.33
.10	631.	67.0	18.50

APPENDIX 5

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